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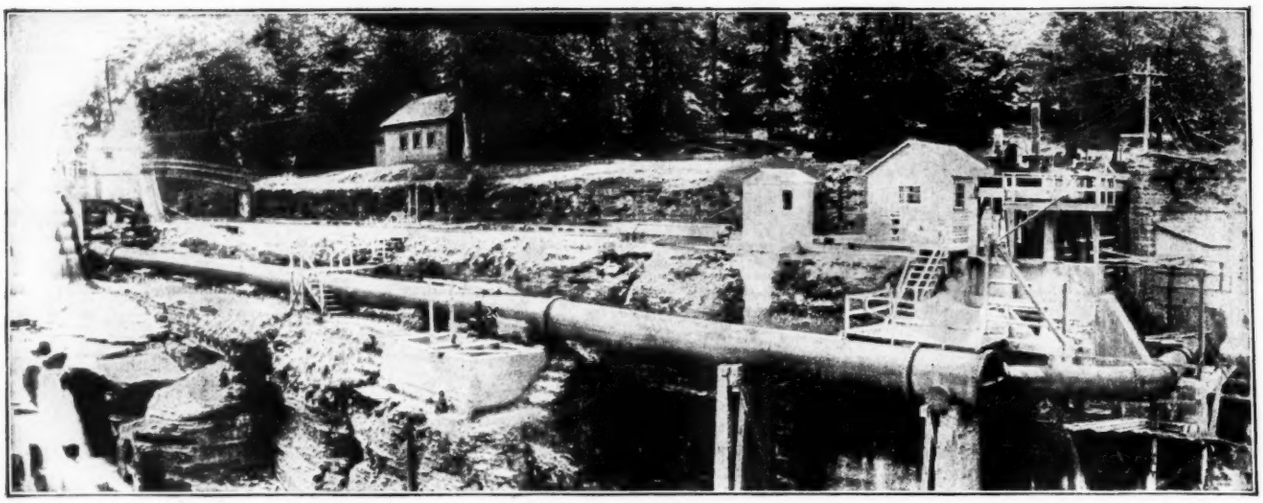
Weeding Out the Drones

THE Chamber of Commerce of the United States has been making a splendid effort to encourage merchants and manufacturers in cutting down expenses to meet present business conditions. The Chamber has been most encouraged by one form of reply to its question, "Are you reducing the number of your employees?" This reply typically, "We are weeding out the drones and keeping our efficient men."

Power-plant engineers doubtless already have done this same thing with respect to the fire-room and engine-room force, but that is not enough. Every responsible plant manager should see to it that he has given equal attention to the equipment and accessories of his plant. Here, however, it is not so much the idle equipment but the inefficient that must go.

During times of peak demand it is difficult to find opportunity for readjustment, replacement or repair of operating facilities that still can be made to function with passable efficiency, but in a time of slackened operations there is no excuse for allowing only passable facilities to remain. Nothing short of the best practicable operating efficiency should be accepted from any part of the plant. Under present conditions equipment often can be spared from service for a time to permit adjustment or repair to good advantage. Overhauling equipment is thus feasible now which would be wholly out of the question under many other conditions.

It will pay well to look about and find the mechanical drones and weed them out at once if they cannot be converted into useful and efficient members of the plant.



New Method of Water Measurement in Efficiency Tests of 37,500-Hp. Turbines*

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The efficiency tests of three 37,500-hp. units in station No. 3 extension of The Niagara Falls Power Company are described, with particular reference to the application of the author's new inventions for measuring the flow of water in penstocks, which have become known as the Gibson Method and Apparatus (patents applied for). One per cent of the present allowable diversion on the American side of Niagara Falls is sufficient to develop four thousand horsepower in the existing plants, therefore it is necessary to determine by adequate means the efficiencies of the waterwheels. In the new method the flow is measured by utilizing a record which is made of the changes of pressure that occur in the penstock when the turbine gates are gradually closed.

ON ACCOUNT of the restrictions placed by law on the diversion of water for power purposes from the Niagara River the measurement of the quantity used in the various plants is a matter of extreme importance. According to the terms of a treaty between the United States and Great Britain each country is permitted to divert a certain quantity. In the United States this quantity is 20,000 cu.ft.-sec., and the Niagara Falls Power Co.'s allotment is 19,500 cu.ft.-sec. The terms of this treaty are being rigorously observed, and in the observance the output in kilowatts of the power company's plants must not at any time exceed the capacity that will utilize its allotted quantity of water. To determine the relation between power and discharge of a unit it becomes necessary, therefore, to measure the quantity of water used and to determine the efficiency of the turbine. The importance of this measurement and the accuracy desired will be appreciated when it is considered that 1 per cent of 19,500 cu.ft.-sec. would generate in the existing plants at least 4,000 hp.

When the three new 37,500-hp. turbines were installed and ready for operation the company was then in a position to use all the water to which it was entitled and the regulating authorities fixed the efficiencies of the new units at a point which it was believed would not be greater than the actual efficiencies.[1] Possibly the efficiency was fixed low enough to make it worth while for the company to go to the expense of proving the exact efficiency. In any event the results were not disappointing because, after making the official tests, which received the approval of the Government's division engineer, the allowable output from the three units, when charged with the same quantity of water as formerly, was increased by nearly 5,000 horsepower. Shortly before these units were installed the author had invented a new method of flow measurement, which has since come to be known as the Gibson Method, and which seemed to offer many advantages, particularly in the case of large units supplied with water through closed conduits. This method was the outcome of studies of the changes of pressure in penstocks caused by the gradual closing of turbine gates, which appeared in the form of a paper published by the American Society of Civil Engineers in April, 1919. The company is fortunate in having in John L. Harper a chief engineer of broad vision and unlimited courage, so that when the new method of measurement was proposed

*Abstract from a paper presented at a joint meeting of the Engineers Club of Philadelphia and the Philadelphia sections of the American Society of Civil Engineers, American Institute of Electrical Engineers and American Society of Mechanical Engineers.

[1]A detailed description of this installation appeared in *Power*, Sept. 14, 1920.

to him it received at once his full support and the inventor was given an opportunity to develop the method and apparatus for its application.

It is not the intention in this article to give a mathematical analysis of the method or to present a detailed description of the apparatus employed. However, it may be stated that the method makes use of two well-known principles, the first being Newton's second law of motion, sometimes referred to as the equation of impulse and momentum, and the second being a corollary of the first; namely, the relation between change of pressure and change of velocity of a column of water expressed in terms of the velocity of the pressure wave. The application of these two principles

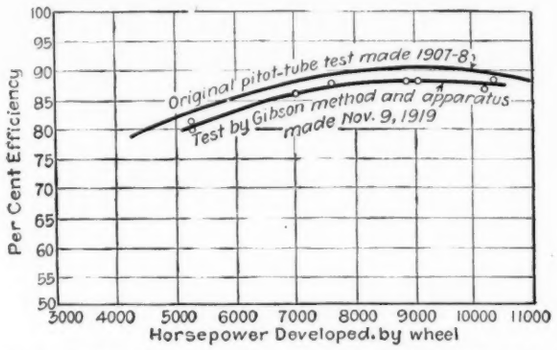


FIG. 1. FIRST EFFICIENCY CURVE FROM RESULTS OF WATER MEASUREMENT USING THE GIBSON METHOD AND APPARATUS

makes it possible to determine the mean velocity of a column of water in a penstock by recording the changes of pressure at a point in the pipe line when the flow therein is gradually brought to rest by closing a valve or the turbine gates. The mean change of pressure recorded is a precise measure of the velocity destroyed.

In practical work it is not always possible to stop the flow entirely, because leakage nearly always occurs through the turbine gates, and in such cases the velocity determined is the difference between the initial and final velocities. The remainder is readily determined in one of several ways, some of which will be referred to later.

The apparatus comprises a new combination of simple elemental parts in which the pressure element is a U-tube containing mercury, the motion of which can be made to correspond in any desired ratio to the change of pressure in the penstock. It provides illumination and records photographically to exact full scale the motion of the top surface of the mercury in the tube and combines in the record the oscillations of a seconds pendulum. The resulting diagrams (see Figs. 5 to 8)

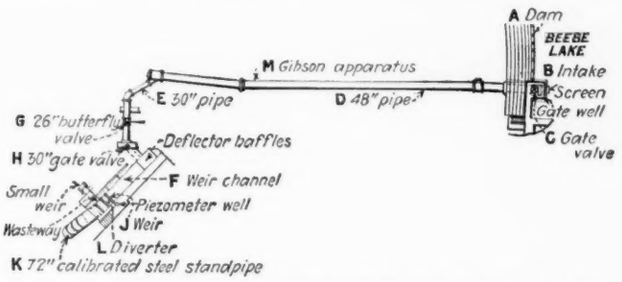


FIG. 2. DIAGRAMMATIC SKETCH SHOWING GENERAL ARRANGEMENT OF EQUIPMENT USED AT THE HYDRAULIC LABORATORY, CORNELL UNIVERSITY

show a complete record of pressure changes and time. The cross-hatched parts of these diagrams are black on the original photographs.

After completing the theoretical studies and after building the first apparatus, which has subsequently been much improved, both theory and apparatus were tested by experiments.

The first experimental equipment comprised a head-water tank feeding a 3-in. wrought-iron pipe 420 ft. long, near the lower end of which was placed a 3-in. globe valve. The flow through this pipe was made to discharge into a measuring tank. By maintaining a constant level in the head tank and opening the globe valve various amounts it was possible to produce a steady flow in the 3-in. pipe at various velocities up to about 4 ft. per sec. The discharge was measured in the measuring tank and then the globe valve was closed by hand. The pressure-recording apparatus was attached to the 3-in. pipe just upstream from the globe valve, and during the closing of the latter the apparatus recorded the changes of pressure in the pipe. The results of these experiments were remarkably satisfactory considering the nature of the equipment, and it was found that the variation of measurements by the new method from

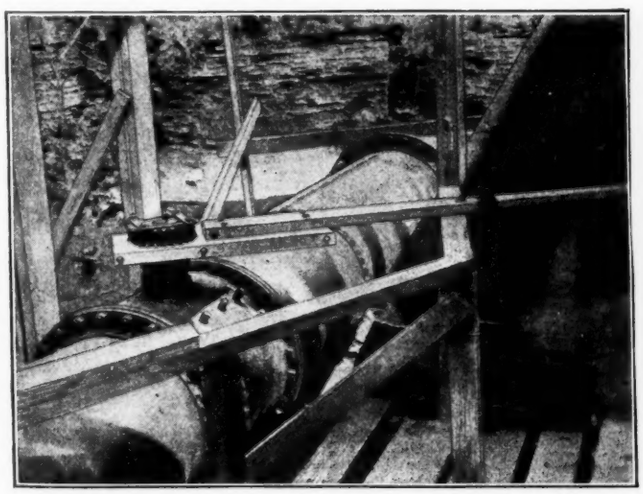


FIG. 3. BUTTERFLY VALVE IN 30-IN. PIPE LINE

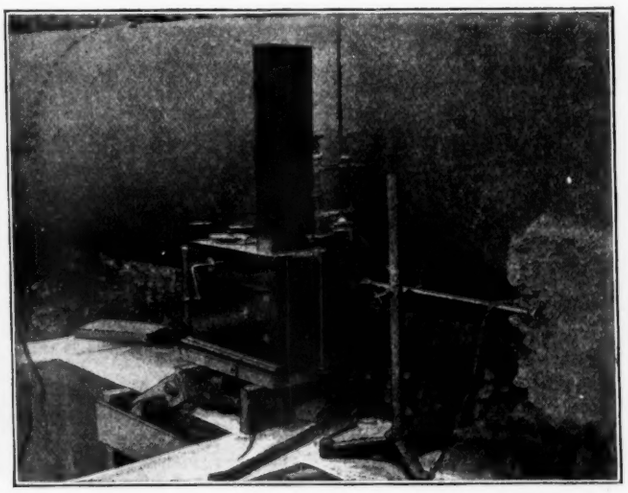


FIG. 4. GIBSON APPARATUS IN POSITION

the volumetric measurements was seldom greater than one-half of one per cent. A typical diagram is shown in Fig. 6, and an interesting one for research purposes only to show the periodicity of pressure waves is shown in Fig. 7.

Following this work a new set of apparatus was built and trials were made not only with the 3-in. experimental pipe, but also on the 9-ft. penstock of unit No. 2 in station No. 3.

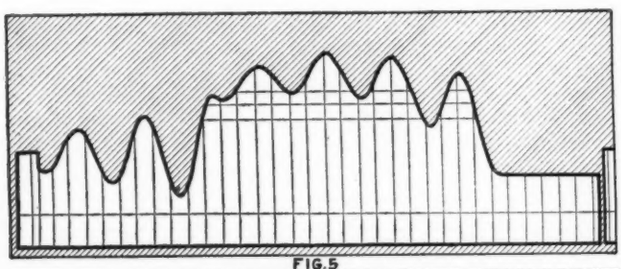


FIG.5

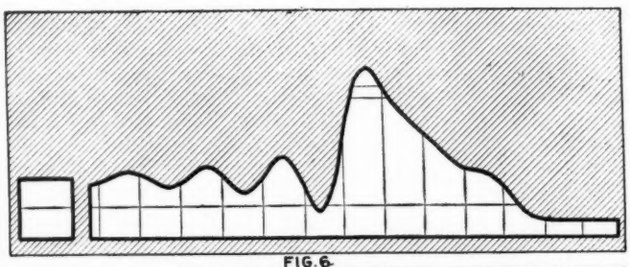


FIG.6

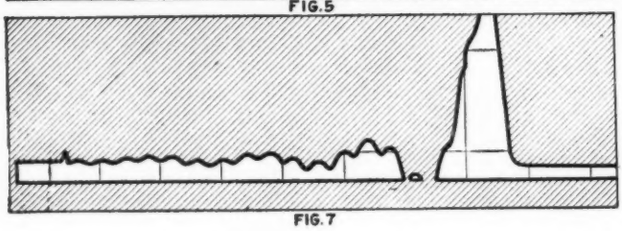


FIG.7

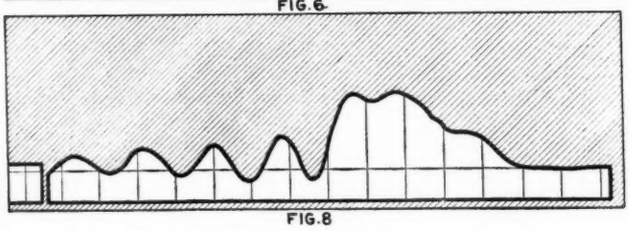


FIG.8

FIGS. 5 TO 8. PRESSURE-TIME DIAGRAMS TAKEN WITH GIBSON APPARATUS

Fig. 5—Typical pressure-time diagram. Tunnel penstock 15-ft. 6-in. diameter, 371.5 ft. long. Diagram obtained by closure of turbine gate. Fig. 6—Typical pressure-time diagram. Experimental wrought-iron pipe 3 in. diameter, 420 ft. long. Diagram obtained by closure of globe valve. Fig. 7—Typical pressure-time diagram. Experimental wrought-iron pipe 3 in. diameter, 420 ft. long. Diagram obtained by closure of globe valve to show periodicity of pressure waves. Fig. 8—Typical pressure-time diagram. Steel pipe at Cornell University 48 in. diameter, 142.63 ft. long. Diagram obtained by closure of butterfly valve.

Fig. 1 shows the first efficiency curve obtained by the new method and just above it the efficiency curve made by pitot tube some years previously on a similar unit. The two curves have the same characteristics, the new one being just a little lower than the old one, which it was considered reasonable to expect in view of the age of the unit.

With this evidence in hand the matter was brought to the attention of the division engineer at Buffalo, who had charge of the water regulation used from the Niagara River, and upon request the company was advised that the new method might be used for determining the relation between power and discharge of the new units then being installed if satisfactory proof were given to him as to the accuracy of the new method or the coefficient that should be used, if any.

At this point some explanation should be given as to why it was desired to use the new method rather than one of the older and well-known methods. One of the most important reasons was that tests could be carried out without serious or prolonged interruption of the supply of power from the unit being tested. It requires a two-minute shutdown for each measurement, and the measurements may be repeated about once every ten or fifteen minutes. A complete set of measurements at each tenth of gate opening from half to full gate may be made in less than two hours, and during that time the unit would be out of commercial service only about fifteen minutes. There were two other reasons that may be mentioned, one being that the trouble and expense of the tests would be much less than by any other method, and the other that it was believed the new method of making the tests was very accurate.

Without going too deeply into theory, the reason for the accuracy of the new method will be appreciated by a reference to the fact that a small change in velocity can be made to produce a relatively large change of pressure. The mean change of pressure corresponding to a change of velocity can be made from five to twenty times the velocity head, or even greater if there were any advantage in doing so. In the pitot tube the velocity head only is observed, or at best by differential methods only some small multiple of this value is obtained. In the new method a record is made with great precision of a quantity that is many times greater than the velocity head. In other words, the quantity observed and recorded is many times greater than, but is proportional to the quantity it is desired to know.

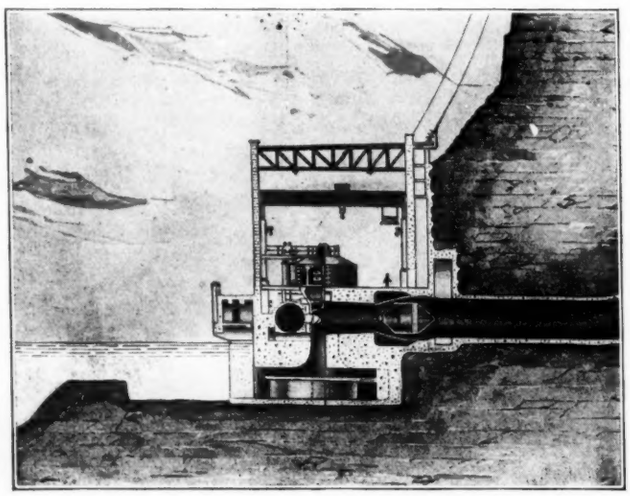


FIG. 9. SECTION THROUGH UNIT NO. 16

It is true, of course, that this change of pressure takes place in a comparatively short time, and the element of time must be considered. It is comparatively easy, however, to measure time accurately. If an interval of 10 sec. is measured within $\frac{1}{10}$ of a second the error is

only 1 per cent, but time may be quite readily measured within $\frac{1}{10}$ of a second in which case the error is only $\frac{1}{10}$ of one per cent. It so happens, however, that in the new method it is not necessary to measure time directly at all, but only the product of pressure and time, which may be done very accurately indeed.

In order to obtain satisfactory proof of the accuracy of the new method of measurement as required by the authorities in charge of the regulation of the use of water, arrangements were made with Dean E. E. Haskell, of the College of Civil Engineering at Cornell University, to have a thorough test made by comparison with volumetric measurements at the laboratory of the university. There is probably no other place where hydraulic experiments of this kind can be made so satisfactorily as at Cornell University.

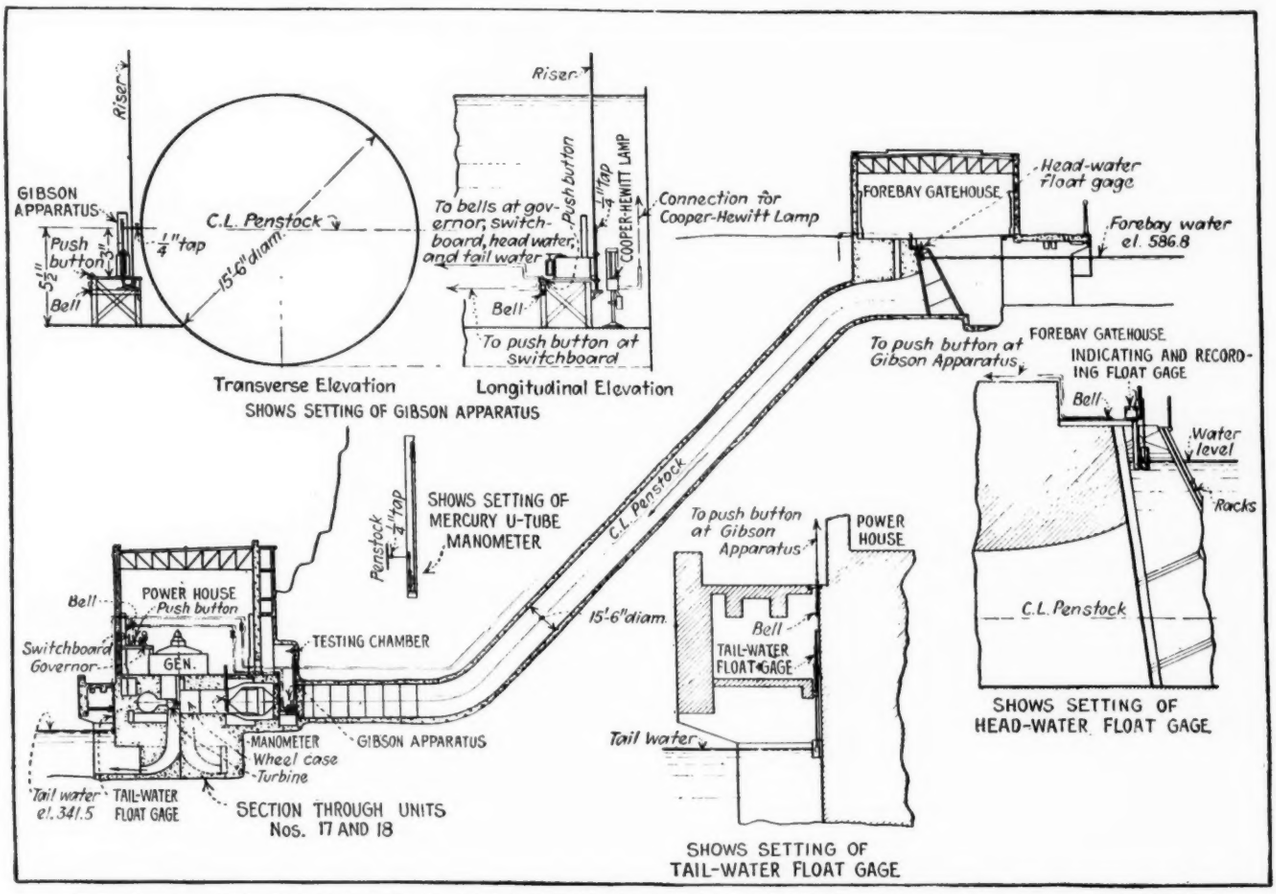


FIG. 10. SETTING OF APPARATUS AND EQUIPMENT FOR WATERWHEEL EFFICIENCY TESTS BY GIBSON METHOD ON 37,500-HP. UNITS

The laboratory work for our tests was carried out under the direction of Dean Haskell and under the personal supervision of Dr. E. W. Schoder, the professor in charge of the laboratory. Dr. Schoder, with the help of his assistants, J. H. Stalker and J. A. Thomas, made the volumetric measurements, and the writer and his assistant, P. F. Kruse, had charge of the Gibson measurements. Some of the work was witnessed by Lieutenant A. B. Jones from the Government division engineer's office at Buffalo, R. D. Johnson, of New York, and George R. Shepard, assistant chief engineer of the Niagara Falls Power Company.

The general arrangement of the equipment used at the laboratory is shown in the diagrammatic sketch, Fig. 2. In the headpiece is shown a general view of the hydraulic laboratory, College of Civil Engineering, Cornell University; the Gibson apparatus is set up over the concrete tank at *X*. A near view of the 26-in. butterfly valve in the 30-in. terminal branch of the 48-in. pipe is shown in Fig. 3. The operating lever 8 ft. long is shown clamped to the framework, which served as a source of friction with downward pressure on the lever. Fig. 4 is a close-up view of the Gibson apparatus set up as during the tests under conditions approximating as nearly as possible at the laboratory the conditions prevailing for efficiency tests at Niagara Falls.

Referring to Fig. 2, *A* is the dam which impounds water in a comparatively large reservoir, and at the south end of the dam is the intake *B* to a 48-in. steel conduit. The intake comprises a submerged orifice protected by steel screen bars and a gate well into which the water flows before it enters the pipe. A 48-in. rising-stem hand-operated gate valve *C* controls the flow into the pipe.

The 48-in. pipe *D* extends for a distance of 198.37 ft. to a dead end. At about 4 ft. from the end a 30-in. cast-iron pipe *E* branches off at an angle of about 45 deg. and after passing two bends discharges into the weir channel *F* inside the laboratory building. In the 30-in. branch two valves at the points shown in the diagram were placed—one a 26-in. butterfly valve *G* with reducers, and the other a 30-in. hand-operated rising-stem gate valve *H*.

The weir channel is about 35-ft. long, 6 ft. wide and 7½ ft. deep below the crest of the weir and 11¼ ft. deep below the channel walls. In it are placed heavy baffle boards for stilling the discharge from the 30-in. pipe, and at high flows a timber raft is used in addition for the same purpose.

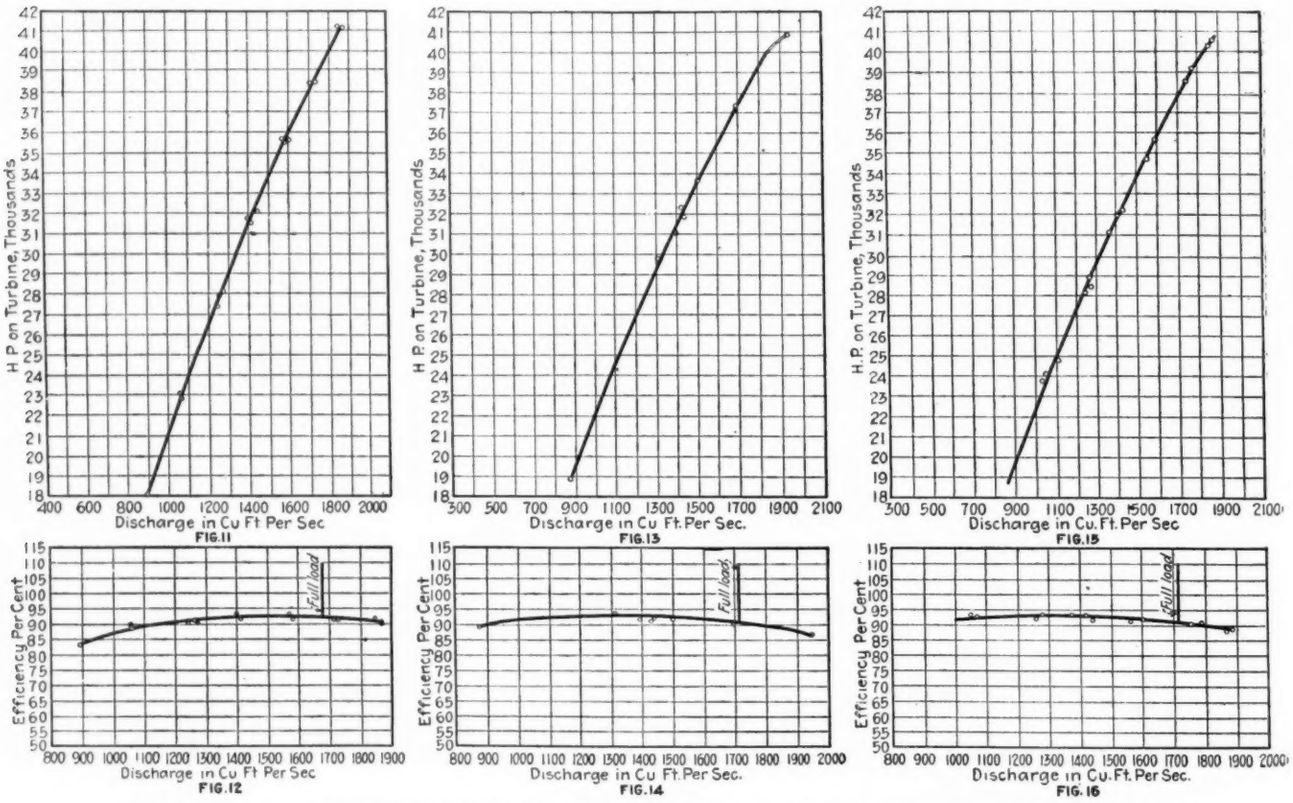
After discharging over the weir *J* the water may be wasted or may be directed into an accurately calibrated steel standpipe *K*, which is 6 ft. in diameter and 60 ft. high. The quantity of water is measured volumetrically in this tank. The elevation of the water surface in it is determined by means of a counterweighted float gage, readings being taken by observations of a steel tape which passes over a pulley. The water is directed into the standpipe by means of a counterweighted diverter *L*, which quickly cuts through the nappe of the water passing over the weir. As the diverter passes through the nappe electric contacts in circuit with a chronograph are closed. The contacts are adjusted to close when the edge of the diverter is at the middle of the nappe.

For the tests the Gibson apparatus was placed as shown in Fig. 2 at *M* and connected to a piezometer opening tapped into the wall of the 48-in. pipe at a point 142.64 ft. from its mouth. A typical diagram obtained is shown in Fig. 8.

On account of the restricted entrance into the gate well at *B* and the consequent loss of head there was considerable surging in the gate well when the flow was shut off during a test. This variation in head-water level had to be accounted for in determining the flow, and the changes of level were obtained by recording the height of a float gage in the well. For convenience this was done by fitting up a second Gibson apparatus for the purpose, which simply photographed the motion of an arm attached to the float gage, the photograph thus obtained being a record of the changes of level of the water in the gate well during a test.

Six series, 20-E, 30-A, 40-A, 40-C, 50-A and 50-C, comprising in all 19 tests, were made under conditions approximating as nearly as could be had at the laboratory the conditions prevailing for efficiency tests at Niagara Falls. The results of these tests are given in the table, from which it is seen that the average of all measurements made by the Gibson method agrees within less than 0.2 of one per cent with the average of all the volumetric measurements. The maximum variation of any one series is 0.8 of one per cent.

A careful analysis of these results has been made, which indicates that part of even the slight variations between the volumetric measurements and measurements by the new method may be explained by a very slight unsteadiness of flow, which is sufficient to account for some of the difference between the two measurements. This unsteadiness seems to be characteristic of all water flowing above the critical velocity, and while difficult to account for, it was manifest in this case by the variations in the level of the water passing over the weir before it entered the measuring tank. The magnitude of the variations in gage height was an index of the magnitude of the variations in flow. It would be natural, of course, that variations in the measurements due to this cause would be both positive and negative, and the mean of a series of results would not show differences of the



FIGS. 11 TO 16. EFFICIENCY-DISCHARGE AND POWER-DISCHARGE CURVES FOR 37,500-HP. UNITS

Fig. 11—Power-discharge curve unit No. 16. Fig. 12—Efficiency-discharge curve unit No. 16. Fig. 13—Power-discharge curve unit No. 17. Fig. 14 — Efficiency-discharge curve unit No. 17. Fig. 15—Power-discharge curve unit No. 18. Fig. 16—Efficiency-discharge curve unit No. 18.

same magnitude as might occasionally be found in any single measurement. The fact that the mean variation between the volumetric measurements and the measurements by the new method is only 0.2 of one per cent would indicate that while there might be a difference between the two methods of measurement for any one observation, each method might be as near perfect as the other because the quantity measured is slightly different in each case.

In addition to the foregoing several very satisfactory tests were made for research purposes, but as they are not concerned particularly with the subject now under consideration the results obtaned will not be recorded here. It might be mentioned, however, that they proved that measurements can be made just as accurately when the conduit is made up of sections of various diameters and that differential measurements can be made by using two sets of apparatus and the length of conduit lying between them.

COMPARISON OF VOLUMETRIC AND GIBSON MEASUREMENTS

Test No.	Field No.	Date, 1920	Discharge, Cu. Ft.-Sec. Volumetric	Gibson	Per Cent Variation	Remarks
20-E-1	45	June 11	20.27	20.31	+0.2	Tube R=1.335
20-E-2	46	June 11	20.42	20.52	+0.5	
20-E-3	47	June 11	20.45	20.65	+0.9	
			20.38	20.48	+0.5	Mean of series
30-A-1	5	May 24	30.38	30.51	+0.4	
30-A-2	6	May 25	30.63	.....	.....	Poor diagram
30-A-3	7	May 25	30.69	31.15	+1.5	(not completed)
			30.57	30.82	+0.8	Mean of series
40-A-1	8	May 25	42.24	42.17	—0.2	
40-A-2	9	May 25	41.94	42.28	+0.8	
40-A-3	10	May 25	42.22	42.09	—0.3	
40-A-4	12	May 25	.....	41.96	.....	Volumetric not taken
			42.13	42.12	0.0	Mean of series
40-C-1	30	June 4	40.36	40.41	+0.1	
40-C-2	31	June 4	40.36	40.90	+1.3	
40-C-3	32	June 5	40.98	40.88	—0.2	
			40.57	40.73	+0.4	Mean of series
50-A-1	15	May 29	46.82	.....	.....	Film fogged, diagram invisible
50-A-2	16	May 29	46.95	46.60	—0.7	
50-A-3	17	May 29	46.98	46.60	—0.8	
			46.92	46.60	—0.7	Mean of series
50-C-1	33	June 7	50.30	49.95	—0.7	
50-C-2	34	June 9	50.66	51.47	+1.6	
50-C-3	35	June 10	50.93	51.15	+0.4	
			50.63	50.85	+0.4	Mean of series
Total of means.....			231.20	231.60	—0.2	Mean variation of all tests

Having thus established by careful experiments the accuracy of the new method, the official efficiency tests of the three new units in station No. 3 extension, of the Niagara Falls Power Co., were made on June 29, Aug. 8, and Aug. 17 respectively.

In describing these tests a brief reference will be made to Figs. 9 and 10, which show a cross-section of the new plant, including forebay, penstock, power house and the new units. The lower end of the penstock tunnel is lined with steel plate, and just before it connects with the Johnson valve the lining forms a steel pipe passing through a testing chamber which has been made at the rear of the power house. Originally this testing chamber was designed for the use of pitot tubes, but it serves very well as a place in which the apparatus for recording the changes of pressure in the penstock may be set up. The setting of the apparatus and other test equipment with reference to the adjacent parts is also shown in Fig. 10.

The general procedure for the test by the new method was as follows:

1. The physical dimensions of the interior of the penstock were measured from field data and available drawings.

2. Prior to all the tests that were made on any one unit a leakage test was made to determine the quantity of water that leaked out through the turbine gates when closed. This is necessary in the new method because only the flow actually shut off is measured and whatever remains must be added to the total discharge. A leakage test of this kind is a simple matter. The turbine gates are closed and pressure is maintained in the regulating cylinders. The stop gates at the upper end of the penstock are then put in place and the water in the penstock gradually leaks out through the clearance spaces around the turbine gates. As the water leaks out the fall in pressure of the water in the penstock is observed by means of an ordinary pressure gage and the time and amount of each observation recorded. Then a diagram is plotted which indicates the rate at which the water has leaked out. In some cases the leakage through the stop gates at the upper end of the penstock was considerable, and in order to correct for this the Johnson valve, which is very tight, was closed and the rate of rise of pressure in the penstock recorded as the water leaking past the headgates filled it up. This determined the rate of leakage through the headgates which could be used in obtaining the correct leakage through the turbine gates.

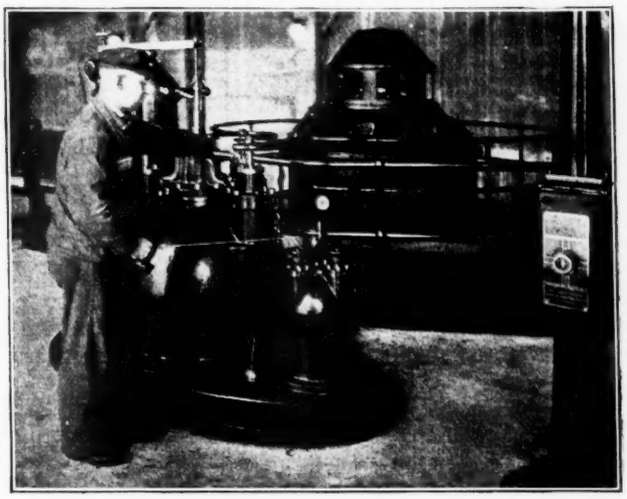


FIG. 17. VIEW OF GOVERNOR OF UNIT NO. 16, SHOWING HAND CONTROL AND MANNER OF OPERATING IT DURING THE TESTS

3. Having completed this preliminary work, the apparatus was attached to a ¾-in. piezometer opening tapped into the wall of the penstock as shown in Fig. 10.

4. Headwater and tailwater float gages were placed in the forebay and tailrace for observing the elevations of headwater and tailwater during a test.

5. A system of electric signal bells was established, the control buttons being placed in the testing chamber near the operator of the apparatus. When ready the assistant in the testing chamber could signal to the observers at forebay and tailrace and to the governor operator.

6. For observing the net head on the turbine a U-tube mercury manometer was set up with a connection to the penstock just at the entrance to the turbine casing. Two observers recorded the elevations of the surfaces of the liquid in the two legs of the U-tube. This gage was calibrated by reference to the total static head when the water was at rest.

7. The unit being tested was synchronized with other units in the plant and allowed to run on steady load with the gates fixed for several minutes, and then it was shut down at a given signal by operating the hand-control pilot valve on the governor. This hand control and the manner of operating it on one of the units is shown in Fig. 17. A cord was wound around the stem of the valve, and on a given signal the operator pulled the cord, which spun the pilot valve wide open. The pressure fluid then flowed to the regulating cylinders which operated the gates, and they were closed just as fast as the fluid could flow through the connecting pipes into the regulating cylinders. The connecting pipes can be throttled to reduce the speed of closing if necessary. On other units the pilot valve is opened by means of a handwheel, but the effect is the same. The duration of closure was usually from about 8 to 18 sec., depending on the amount of gate opening.

Immediately preceding and during the closure of the gates and for a short time thereafter the apparatus recorded the changes of pressure in the penstock, forming a diagram similar to that shown in Fig. 5. As the gates of the turbine closed, the load on the generator was transferred automatically to the other units operating in synchronism with it, sufficient capacity having been left available for that purpose and the unit under test being then driven as a motor at synchronous speed.

8. For two minutes prior to the shutdown the power output of the generator was determined by periodic readings of a calibrated indicating wattmeter attached to the generator leads through calibrated current and potential transformers. The power output of the turbine was obtained by using the efficiency of the generator, which was determined by the company's electrical engineers.

9. Periodic readings of headwater and tailwater gages were also made for the two-minute period prior to the shutdown and for a short time thereafter.

Several Diagrams Taken at Each Gate Opening

It required about two minutes to make a single measurement, and measurements could be repeated about once every ten or fifteen minutes, or at the rate of four or five to the hour. In this way a complete set of diagrams was obtained for each unit at various gate openings. On account of the ease with which diagrams can be made several were taken at each gate opening so as to obtain an average result, and in all from 16 to 18 diagrams were made for each unit. The explanation of the delineation and measurement of the diagram properly belongs to a consideration of the theory of this method of measurement, therefore will not be considered here.

After velocities had been calculated from the diagrams and discharges and effective heads computed, the usual power discharge and efficiency curves were prepared. Some of these are shown in Figs. 11 to 16. From these will be noted the remarkable uniformity in the determination of the points along the power discharge curves, from which it may be concluded that the errors of observation, or so-called variable errors, are extremely small. The absence of any inherent or consistent error was demonstrated by the tests made at Cornell University.

In conclusion attention may be drawn to some of the advantages of the new method of measurement where it may be applied:

1. Remarkable accuracy in the determination of the velocity of flow because small changes of velocity result in comparatively large changes in the pressure to be recorded.

2. Determination of velocity may be made without serious or prolonged interruption of the commercial supply of power from the unit being tested.

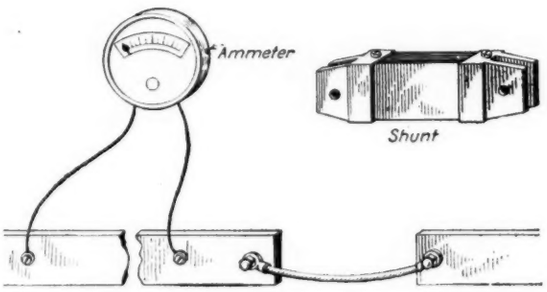
3. Each determination of the velocity of flow may be made quickly in one operation; tedious methods involving tabulation of observed results are avoided.

4. The process is essentially simple and inexpensive. Special appurtenances in the pipe line are not required.

An Emergency Shunt

While the electricians were changing some connections in the rear of a switchboard recently, a heavy lead suddenly dropped over against the station-ammeter shunt and the resulting short-circuit severely damaged the plates. Fortunately, however, the instrument to which it was connected was not injured, so it was decided to return the shunt to the manufacturer for new plates.

In the meantime it was necessary to have some indication of what the current actually was, and as there was no other shunt available, the gap was closed up and the ammeter (millivoltmeter) was connected



CONNECTIONS OF METER TO BUSBAR

across a span of six feet of copper busbar, as in the figure, which acted like a shunt. The original shunt was for 1,000 amperes, giving 50 millivolts drop, consequently it had a resistance of $\frac{0.05}{1,000} = 0.00005$ ohm.

The busbar has a cross-section of 4 x ¼ in., or 1,000,000 square mils, and as copper has a resistance of 8.14 ohms per square mil-foot, then the bus would have a resistance of $\frac{8.14}{1,000,000} = 0.00000814$ ohm per foot and six feet would have a resistance of $0.00000814 \times 6 = 0.0000488$ ohm.

This closely approximated the resistance of the shunt, especially as the resistance increases slightly when the current is on. In using a busbar for an emergency shunt, care must be taken that the meter spans only solid copper busbar and not any joints which might increase the resistance, also that the bar is made of pure copper and not cast copper, as there are some copper bars which have slight percentages of impurities which lower the conductivity to 30 or 40 per cent of pure copper.

Parallel Operation of Compound Generators

Characteristics of Compound Generators—Arrangement of Switches and Adjustment of Voltage—Relation of Equalizer to Armature Polarity—Three-Wire Generators in Parallel—Three-Wire and Two-Wire Machines in Parallel

BY A. M. BENNETT

SUCCESSFUL operation of compound generators in parallel depends on the fulfilling of conditions which will permit of their being switched on or off the system as occasion may demand, and which, when two or more machines have been thrown together, will insure the proper division of load between them. With a given voltage on the system the switching on of another generator must be done with the least possible disturbance, either temporary or permanent, to the existing voltage, otherwise annoying fluctuations will occur on lighting circuits, and on power circuits the speed of motors will be affected.

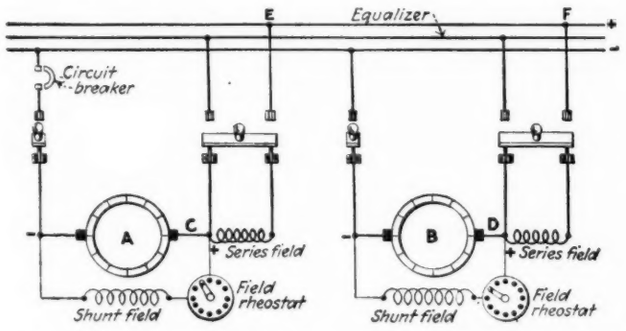


FIG. 1. CONNECTIONS FOR OPERATING TWO TWO-WIRE COMPOUND GENERATORS IN PARALLEL

In order to run in parallel, generators do not have to be of the same capacity or speed, or even of the same make, but precautions must be taken that each carries only its proportionate share of the total load existing on the system. The fulfilling of these conditions depends on the design of the generators, their method of installation, and the proper adjustment of voltage at the time of paralleling.

CHARACTERISTICS OF COMPOUND GENERATORS

Compound generators, on account of their inherent feature of self-regulation of voltage under varying conditions of load, lend themselves readily to the carrying out of the requirements outlined, and in order to consider their relations and behavior when thrown together, the case of two machines of like capacity and design will be taken. These, when driven at the same speed and with the same adjustment of current in the fields, will generate approximately the same voltage at no load. With equal load on the two machines their compounding effect will also be approximately alike and the voltage drop in their series fields will be the same. However, even with the most careful design and manufacture, it would not be possible to have exactly the same voltage obtain at the terminals of the two machines under all conditions of load and speed, and if connected in parallel, the generator having the higher voltage would take more than its share of load. This increase in current would result in a further increase in voltage, due to increased series-field excitation, while the other generator, owing to lessened load, would suffer a decrease in voltage. This unbalance of voltage and load would thus continue till one of the generators was carrying all the load.

In order to correct the foregoing action, the voltage must be increased on the generator working under the lesser load, and this can be done only through its series fields. For this purpose resort is had to what is known as an equalizing connection, which is a line connecting the series fields of the two machines at the points where the latter connect to the armature. This connection is shown in Fig. 1 by the lines from the points *C* and *D* connecting to the equalizer busbar on the switchboard. Any number of generators may be connected after this manner by running an equalizer from each of the busbars. It will be seen that through this connection the series field of each generator is brought under the influence of the other machine, and it is this mutual action that restores the magnetizing balance of the series fields of the two generators and enables the one running under decreased voltage to again assume its proper share of load. This action is as follows:

With equal voltage on the two generators, points *C* and *D* will be at the same potential, and no current will pass between them through the equalizer, the full output from each machine passing through its own series field. Should the voltage at the terminals of generator *A* increase beyond that of *B*, there will be a corresponding difference of potential between the points *C* and *D*, that at *C* being the higher. Current will now flow from *C* through the equalizer to *D* and thence through the series fields of *B* to the positive busbar. The excitation of this field will be increased, and consequently the voltage from generator *B* will be raised. This action will continue until the points *C* and

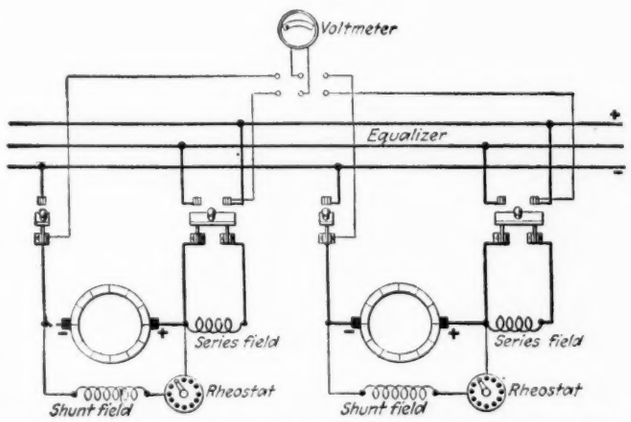


FIG. 2. VOLTMETER CONNECTION TO TWO GENERATORS FOR PARALLEL OPERATION

D have again been brought to the same potential and the load is again properly divided.

If the voltage of *A* had decreased instead of increasing, the reverse action would have taken place; *C* would have been at a lower potential than *D*, and current would have passed through the equalizer from *D* to *C*, through the series field of *A* to the positive busbar. Thus it is seen that the equalizer may be carrying no current at all or may be carrying current in either direction, depending on the momentary terminal voltage of the generators; also, that the current in either series field may be more or less than the corresponding armature current by the amount passing through the equalizer.

In order that the function of the equalizer be not intefered with, it is necessary that its cross-section be sufficiently large to prevent an appreciable drop in voltage along its length. This can usually be insured by making its section the same as that of the mains from the generator. With an equalizer of small section, sufficient current might not flow to restore the unbalance in voltage between the two machines, with the result that one generator might be overpowered and tend to run as a motor.

Voltage Drop in Series Fields

As we have chosen for the foregoing example machines of like capacity and design, the resistance of the series fields will be approximately the same in both. As the two sets of series fields are in parallel by reason of the equalizing connection, the same amount of current will flow in each, and this condition will obtain whether current is flowing in the equalizer or not. In other words, the voltage drop in the two fields is the same. This condition of equal drop will also obtain for generators of different capacities, for the reason that the current in the two sets of series fields must be in direct ratio to the generator outputs, which means that the fields must be designed so that their resistances are in inverse ratio to the generator outputs. With these in

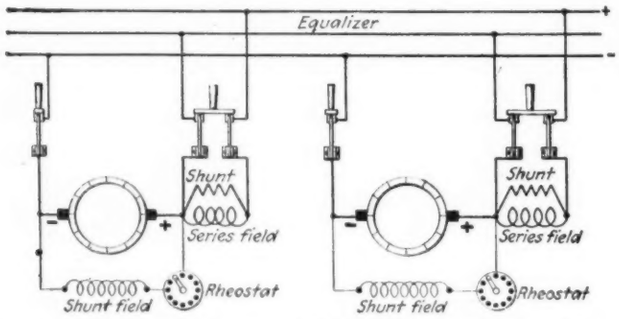


FIG. 3. INDICATES HOW SERIES-FIELD SHUNTS ARE IN PARALLEL WHEN GENERATORS ARE OPERATED IN MULTIPLE

parallel the current flowing in each field will be in inverse ratio to these resistances, or in direct ratio to the generator outputs. The voltage drop in the two sets of fields will therefore be alike, and this may be stated as one of the fundamental requirements for paralleling.

In practice the drop in the lead connecting the series field to the busbar must also be taken into account, and referring to Fig. 1 this requirement is usually stated by saying that the drop from *C* through the series field to *E* must be the same as that from *D* to *F*. If one of these circuits is deficient in resistance, this may generally be made up by inserting an extra length of cable in this circuit, which would be that from the generator which was taking more than its share of load. This extra resistance is best determined by experiment and must not be added to the equalizer circuit.

Arrangement of Switches

The usual arrangement of switches for compound generators is as shown by Fig. 1; that is, a double-pole switch in the equalizer and line from the series field, and a single-pole switch in the line from the other side

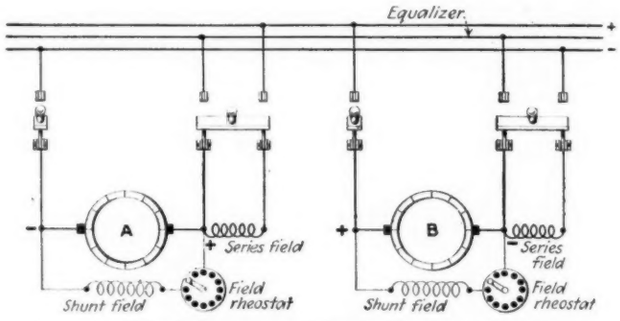


FIG. 4. INCORRECT CONNECTIONS FOR PARALLEL OPERATION OF GENERATORS

of the generator. When a second machine is to be started and connected to the line, it is necessary that its voltage be carefully adjusted. All switches connecting the generator to the line should be open. The generator is brought up to speed with the field rheostat cut in and the voltage then adjusted till it is approximately the same as that of the line. The double-pole switch is then closed and the voltage again adjusted until it is the same as, or slightly higher than, the line voltage, when the switch in the other main can be closed, putting the generator in circuit. By closing the double-pole switch first, the series field of the incoming machine is connected to the line, and the generator is equalized before it is thrown into circuit, with the result that there is less likelihood of voltage disturbance on the line. A method sometimes used to insure this end, is to connect the voltmeter so that it is not in circuit until the equalizer switch is closed, as in Fig. 2.

An alternative arrangement of switches much used, is to connect all three leads from the generator to a three-pole switch, which is closed after the generator is brought up to voltage. The disadvantage of this arrangement is that the generator is not equalized before it is connected to the line. It might be well to point out that under no consideration should the switches be closed when the generator is not running. From Figs. 1 and 2 it will be seen that under this condition the armature of the generator would be thrown directly across the line, and with no voltage being generated in it, a violent short circuit would result.

Adjustment of Compounding

Before it is attempted to run generators in parallel, they should be separately adjusted under full load, so that all compound by the same amount, starting with the same no-load voltage. In the case of new machines this requirement is generally part of the specifications under which the generator is furnished, and is taken care of at the factory. This adjustment is made by means of the shunt across the terminals of the series field, and

should not be changed when the generator is put into service, unless it is found that the compounding as specified is not obtained.

It is sometimes attempted to correct a tendency not to parallel by adjusting the series shunts, but inasmuch as these are in parallel themselves, and in parallel with the series fields, as shown in Fig. 3, a change in one shunt affects the voltage of all generators. If the compounding of each generator is carefully adjusted and they will not share their load properly, then adjustment should be made to the resistance of their series-field circuits, as previously described.

Equalizer and Armature Polarity

In connecting compound generators to their busbars, it is not only necessary that equalizing connections be made at the junction of the armature and series fields of each machine, but it is of the utmost importance that this connection be on the same side of each machine; that is, either on the positive side or on the negative side of each. This means that the series fields of each generator should be connected to the same armature terminal, and this connection is usually made to the positive terminal. An inspection of Fig. 1 will make this point clear. The free end of the series field in this case then becomes the positive lead from the generator. Before the generators are connected to the line, this point should be carefully looked after, and if it cannot be determined from the connections, a test should be made with a voltmeter to ascertain the polarity of the generator. After being satisfied that this connection is properly made, the generators can be run under load and their compounding adjusted. Under this condition with the positive terminal connected to the positive bus,

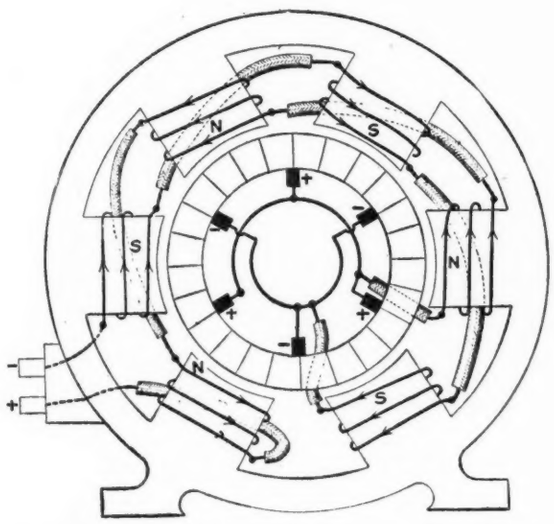


FIG. 5. THREE-WIRE GENERATOR, SHOWING HOW SERIES WINDING IS CONNECTED TO ARMATURE

negative terminal to negative bus, and equalizer to equalizer bus, there will be no danger of a short-circuit when the generators are parallel.

In the foregoing case the series fields of each generator have been connected to the positive terminal, but the equalizer will work as well if the series in each case is connected on the negative side of the generator.

The result of not observing the precautions outlined herein can be seen by Fig. 4, where the series field of one generator is connected to the negative armature terminal, and that of the other to the positive terminal. Though positive, negative and equalizer lines are connected to their proper busbars, it can be seen that the armature of one generator is short-circuited by the series field of the other when the switches are closed.

Disconnecting Generator from Line

In throwing a generator out of circuit, the voltage is reduced by means of the rheostat till the ammeter shows practically no current being delivered to the line. The

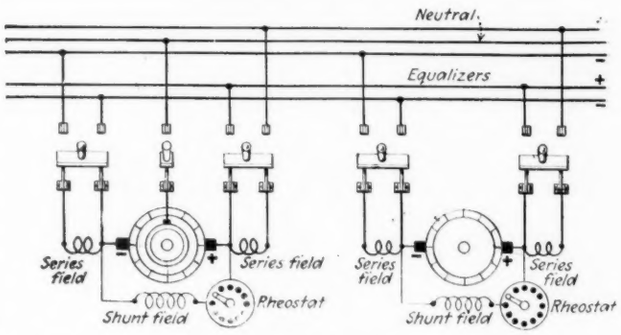


FIG. 6. CONNECTIONS FOR OPERATING TWO THREE-WIRE GENERATORS IN PARALLEL

generator switch or circuit can then be opened without dangerous flashing. It will be found that comparatively little resistance will have to be cut in by the rheostat to reduce the generator current to the required amount. It is only necessary to reduce the internal voltage of the generator to the point where it is the same as the line voltage, when the generator will cease to deliver current to the external circuit. This can be seen when it is considered that the internal or total voltage of the generator is greater than the line voltage by the amount of voltage drop in the generator due to its internal resistance. Consequently, the nearer the internal voltage approaches that of the line, the less current will be delivered. If this voltage be still further reduced, so that it becomes less than the line voltage, the generator will begin to draw current from the line and run as a motor, in which case the generated voltage becomes a counter-electromotive force, limiting the current taken by the machine. It is therefore not desirable to introduce more resistance into the field circuit than is necessary to remove the load from the generator.

Ammeters and single-pole circuit-breakers should be connected in the line opposite the equalizer, Fig. 1. By this means the total current from the generator passes through these instruments, whereas if placed in the lead on the same side as the equalizer, they would not be influenced by the current passing through the latter.

Three-Wire Generators

Three-wire generators are always compound wound and may be paralleled as readily as two-wire machines. In order to provide for compounding under all conditions of unbalancing, the series fields of such generators are arranged in two sections, alternate poles being connected in series, one section being connected to the positive side and the other section to the negative side of the armature, as in Fig. 5, which shows the series winding only on the polepieces. Two equalizers are thus required, one for each section of the series field. Fig. 6 shows the connections for two generators. It will

be seen that the full potential of the generators exists between the two equalizer busbars, the same as between the mains. The action of the equalizer is the same as in the case of two-wire machines, serving as a path for current from a higher to a lower potential. All precautions as to voltage and compounding adjustment outlined for two-wire generators, apply equally to three-wire machines.

Three-wire generators may also be operated in parallel with two generators without difficulty, by arranging

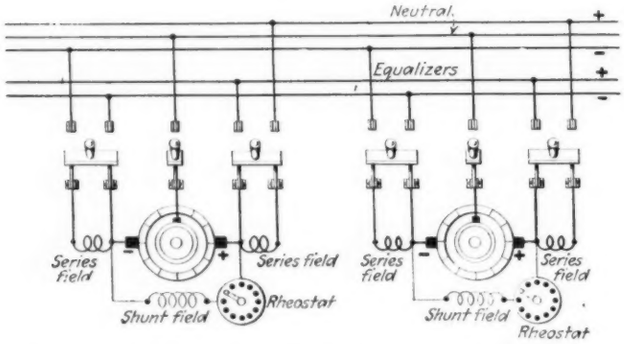


FIG. 7. CONNECTION FOR OPERATING A THREE-WIRE AND A TWO-WIRE GENERATOR IN PARALLEL

the series fields of the latter in two sections, and using two equalizing connections, Fig. 7. The unbalanced load will be taken care of by the three-wire generator, while the two-wire machine will increase the capacity of the system on the outside lines.

From the foregoing it will be seen that for successful parallel operation the following conditions must be satisfied:

1. The generators must be separately adjusted under load so that each is compounded by the same amount.

2. The voltage of the incoming generator must be the same as, or slightly higher than, that of the line, and the generator should be equalized before being connected to the line.

3. The resistance of each series field and its connection to the busbars must be such that at full load the voltage drop in these circuits will be the same for all generators.

4. The series fields of all generators must be on the same side; that is, all connected to the positive, or all to the negative armature terminal. By this means the equalizer will be on the same side in all generators.

5. Positive, negative and equalizer lines from each generator must be connected to positive, negative and equalizer busbars respectively.

6. The equalizing connection must be of ample cross-section to insure its action not being defeated.

More Coal-Saving Nostrums

For one reason or another the annual crop of "Magic Compound" literature seems to be a little late this year, but there are at hand the usual number of communications from *Power* readers inclosing advertisements of various "coal-saving" mixtures to be applied to coal either dry or wet, but preferably the latter, because as one pamphlet flatly states, "you actually burn water." From the list, which contains such familiar names as Fyrox, Kemkom, Calorigene, Carbonine, Fuelade, etc., "Koal-Save" is selected as affording an edifying illustration of the business methods of this class of enterprises. The "Koal-Save" company hails from Chicago, and dwellers in the Land of the Sacred Codfish will be interested to note that the name "Ben Butler" appears on the letterhead as sales manager.

Anyone desiring the agency for this wonderful compound, each package of which is guaranteed to save one third of a ton of coal, can obtain it for a specified territory by making an initial purchase according to the following sliding scale: 6 dozen packages at $6 per dozen, one county; 12 dozen packages at $5.75, two counties; 24 dozen packages at $5.50, four counties; 50 dozen packages at $5.25, eight counties; 100 dozen packages at $5, one state.

Furthermore, all that the would-be salesman has to do to continue his exclusive control of the territory thus acquired is to order at least six dozen packages a month for each county.

That the vendor of this boon to mankind may expect to make the modest profit of 100 to 140 per cent on his investment is shown by the following table of "prices to agents," reprinted verbatim from the circular at hand:

Quantity	Price per Dozen	You Pay Us	You Sell For	Your Profit
100 dozen	$5 00	$500 00	$1,200 00	$700 00
50	5 25	262 50	600 00	227 50
24	5 50	132 00	288 00	156 00
12	5 75	69 00	144 00	75 00
6	6 00	36 00	72 00	36 00

There is apparently nothing in the literature issued by the "Koal-Save" company to show how large its "packages" are, but at the present market rate for salt, the reader can use his own judgment as to this detail, and, without being ungenerous, still succeed in figuring out a reasonably satisfactory profit for the perpetrators of the scheme.

In the course of the series of editorials and red-flag articles which have appeared in the columns of *Power* for years past, the following poem was published, and it is well worth reproducing not only because of its intrinsic merit, but also because, except for the necessary rhyme and rhythm, any of the names mentioned, or in the future to be offered to a supposedly gullible public, might be substituted.

It's made us sore and roused our spleen
No more our mind is gay, serene.
Old Trouble's hit us on the bean
The reason is, Calorigene.

We've burned the midnight kerosene
And scoured the earth that we might glean
Some hope to make our coal bills lean—
Oh, where were you, Calorigene?

Calorigene, Calorigene!
It is quite plainly to be seen
That you have acted doggone mean
To keep yourself so long unseen.

Could we from you one small hope glean
We'd crown you queen, Calorigene,
If you could save one-half the coal
That's swallered by the furnace hole!

Calorigene, Calorigene,
Say; if you're hep to what we mean—
If, when we reach that blessed shore
Where coal and ashes are no more,
Calorigene, if you prove true,
We'll back to earth and stay with you!

Of the gas and oil engines now being imported by Argentina about 90 per cent are from the United States, instead of 50 per cent, as before the war.

John Hunter

Chief Engineer. Heine Safety Boiler Co.

BUOYED up with the proverbial Scottish good humor and genial personality and trained to his work in the hard school of experience, it is little wonder that John Hunter has reached his present position in the front ranks of power-plant engineers. It was in 1866 that he was born in Girvan, Scotland, and from the time when he finished his mechanical-engineering and shipbuilding apprenticeship in his native land to the present, he has devoted his life almost entirely to the operation, improvement and design of power-producing apparatus. His seagoing career began with his appointment as junior engineer on the "Westernland," of the Red Star line, and gave early signs of promise in his promotion to the position of first assistant engineer on the "Friesland," of the same line. In 1895 he was transferred to the "St. Louis," of the American line, then being built at Cramps' Shipyard in Philadelphia. His position here was senior first assistant engineer. He served in this capacity until the outbreak of the Spanish-American War in 1898, when he was appointed chief engineer of the "St. Paul," which was operated by the United States Navy, with Captain Sigsbee in command. After the war the "St. Paul" was returned to commercial service, operating between New York and Southampton, and he continued to serve as chief engineer until 1905.

JOHN HUNTER

Then the erstwhile mariner deserted the sea, for a time, at least, to take up stationary power-plant work with the Union Electric Light and Power Co., of St. Louis, as chief engineer of all that company's plants. Mr. Hunter's work here consisted in the design, construction and operation of the electric generating stations of the company, which supplied practically all the lighting and industrial power, together with a considerable share of the street-railway power, of St. Louis. These duties naturally gave him a wide opportunity for creative effort, notably in the Ashley Street Station, the largest of the system and the scene of much pioneer development work. An idea of the kind of work that Mr. Hunter did here may be had from a comparison between the original rating of the Ashley Street Station, 12,000 kw. when he took charge, and the later rating of 116,000 kw. in the same building, resulting from his introduction of the latest improvements and apparatus. In this connection he was closely identified with the early development of high-capacity turbine units, condensers and improved methods of setting boilers and designing furnaces for high capacity operation. For the sake of variety, perhaps, he went into hydro-electric development in 1913 with Hugh L. Cooper, of the Keokuk Water Power Co., in the building of a hydro-electric plant which ultimately furnished the Union Electric Co. in St. Louis with 60,000 hp. over a 100,000-volt transmission line. When the United States was drawn into the war in 1917 and the country's cry was for "ships, more ships!" Mr. Hunter was called East by the Government to assist in the shipbuilding program. He was first detailed as Government representative in charge of the Submarine Boat Company and afterward was transferred to the Standard Shipbuilding Corporation, Shooters Island, N. Y., as "Naval Constructor." The number of employees under his supervision in this yard increased from something over 850 in 1917 to approximately 8,300 at the time the armistice was signed. Upon the recent dissolution of the corporation he accepted the position of chief engineer of the Heine Safety Boiler Co., where his wide central station acquaintance will be of value.

Mr. Hunter is well-known in engineering circles; he is a member of the American Uniform Boiler Law Society and of the prime movers committee of the National Electric Light Association, and was on the Jury of Awards, Department of Machinery, at the San Francisco Exposition. He served also as president of the Engineers' Club of St. Louis and as manager and later as vice-president of the A. S. M. E.

Maintenance-Department Methods*—II
Organization and Scope

BY HUBERT E. COLLINS

THE chart shows all the classes of help that pertain to the maintenance department. The first three divisions show the classes of men to operate the power plant. Each of these divisions has its own helpers or labor, but otherwise the classes of operatives are clear and distinct.

The foreman of labor has charge of practically all labor for general use in the maintenance department.

There are 23 distinct classes of help enumerated on this chart. They all are to perform maintenance-department functions as will be shown in the write-up of the functions. Many departments of the works will have classes of operatives similar in name, but they are departmental operatives whose time and material are charged off directly to their own departments.

For example, many departments have their own millwrights, laborers, steamfitters, painters and carpenters; in fact, there may be works departments of carpenters, painters, etc.; but purely maintenance work of the works is to be performed solely by this organization of the maintenance department.

The functions of the maintenance department should be outlined in a series of instructions issued from the office of the general manager, works manager or superintendent of works. These instructions should be numbered consecutively as they are issued, with the date of issue. They should be issued to all heads of departments in the works and copies kept on file in each departmental office. The head of the works or his representative in direct charge of the production departments should first issue an instruction as follows:

Works Engineer or Maintenance Engineer

.....192.... Instruction No.....

MAINTENANCE DEPARTMENT

1. The Maintenance Department will be organized as shown on the accompanying chart and under the direct charge of the Maintenance Engineer.

Maintenance Engineer:

He shall be the head of the Maintenance Department and in direct charge of the same, reporting direct to the General Manager. (This may be the works superintendent or works manager.)

He shall have charge of "Factory Maintenance and Extensions," "Generation of Heat, Light and Power," "Transmission of Heat, Light and Power," "Factory Protection," "Factory Cleaning," "Safety First," "Fire Department Organization," and his own immediate office assistants.

He will also act as chairman of the Safety First Committee.

a. *Factory Maintenance and Extensions:*

Through his office assistants, foremen of tinsmiths, carpenters, masons, painters, millwrights machinists, plumbers, steamfitters and electricians.

Design, estimate on or install new buildings, or additions, and alterations to same.

Maintain all factory buildings and extensions, and the apparatus contained therein as follows: Mechanical and electrical transmission lines, water and steam lines, sprinkler system, gas storage and transmission, oil storage and transmission, water system transmission, refrigeration system, plumbing, watchmen's clock apparatus and lines, factory telephone and call systems, fire alarm and safety-first devices.

Design, estimate on or install new equipment or apparatus and make alterations in or additions thereto.

b. *Generation of Heat, Light and Power:*

Through his first assistant engineer, boiler-room engineer and electrical engineer.

Operate the power plant and all apparatus connected therewith for the generation of heat, light or any kind of power.

c. *Transmission of Heat, Light and Power:*

Through his assistant engineers and all foremen of his department.

Maintain all transmission lines throughout the works.

d. *Factory Protection:*

Through his foreman of guards and assistant engineer in charge of safety first and factory department.

Furnish protection from fire, theft and other losses.

Maintain proper discipline for protection of property and lives of employees.

ORGANIZATION CHART—
MAINTENANCE DEPARTMENT

First ass't engineer	Engineers Oilers Switchboard men Cleaners Helpers
Boiler room engineer	Firemen Water tender Boiler-repair men Coal passers Helpers
Electrical engineer	Electricians Elevator men Inspectors Helpers
Foreman millwright	Millwrights
Foreman machinist	Machinists
Foreman plumber	Plumbers
Foreman steamfitter	Steamfitters
Foreman tinsmith	Tinsmiths
Foreman carpenter	Carpenters
Foreman mason	Masons
Foreman painter	Painters
Assistant engineer	Fire department Safety first Record clerk
Foreman of labor	Yardmen Truckmen Janitors Labor
Foreman of guards	Guards—watchmen
Storekeeper	Clerk

*This is the second of a series of three articles on this subject by Mr. Collins, The first, "Keeping the Power Plant Records" appeared in the March 15 issue, the third and last, "Distributing the Costs," will appear March 29.

e. *Factory Cleaning:*

Through the foreman of labor.

Keep all yards and buildings clean. The departmental cleaners will take care of the departmental cleaning.

f. *Safety First:*

Through his assistant engineer in charge.

Maintain a safety first committee of which the assistant engineer will be secretary.

Have charge of and be responsible for all fire-fighting apparatus.

g. *Fire Department Organization:*

Through his assistant engineer in charge.

Maintain a fire-fighting organization composed of men in the various departments.

The Maintenance Engineer will operate this department in accordance with these instructions and such other instructions as may be issued from time to time from this office, and with the class of help designated on the chart issued with this instruction.

He will direct all the activities of this department; keep records of time of men, number and names of those employed in the department; material ordered, used and on hand; work performed, under way or contemplated, and draw up and file all location plans of apparatus connected with this department, keep records, etc.

Signed,.....
General Manager.

With this first instruction from the general manager on the subject of maintenance department a copy of the organization chart goes out, one copy of each to all heads of departments in the works.

They define the duties of the maintenance engineer and are his authority for issuing detail instructions to each of his foremen and assistant engineers.

These instructions from the maintenance engineer should clearly define the duties of each man reporting to him and be accompanied by an organization chart with the name of each assistant engineer and foreman on it in the proper place with the title.

A copy of such instructions follows:

....., 192.... Instruction No. ....

MAINTENANCE DEPARTMENT—FIRST ASSISTANT ENGINEER

The first assistant engineer will report direct to the Maintenance Engineer.

He will have charge of engineers, oilers, switchboard men and helpers in the engine room.

Through them he will operate all apparatus in the engine room and everything pertaining to the operation of the same.

He will have charge of all generating apparatus in the engine room, including engines, refrigerating machines, electrical generators, air compressors, hydraulic pumps, or any power generators, to operate them.

He will direct the securing of data from the recording instruments for compilation in the Daily Report made up by the record clerk under the assistant engineer in the Maintenance Engineer's office.

He will see that all men under him conform to the license laws of the city or state before working under him and that all casualty and insurance laws relating to the apparatus and duties of the men under him are complied with.

He will comply with the General Instruction from the General Manager's office as to the handling of this help.

Signed,.....
Maintenance Engineer.

....., 192.... Instruction No. ....

MAINTENANCE DEPARTMENT—BOILER-ROOM ENGINEER

The Boiler Room Engineer will report direct to the Maintenance Engineer.

He will have charge of firemen, water tenders, boiler-repair men, coal passers and helpers of his unit.

Through them he will operate all apparatus in the boiler room and everything pertaining to the operation of the same.

He will operate all boilers, feed pumps, stokers, blowers and feed-water heaters.

He will direct the securing of data from the recording instruments in his department of the power plant for compilation in the Daily Report made up by the record clerk under the assistant engineer in the Maintenance Engineer's office.

He will direct the boiler-repair men in the upkeep repairs of the boilers such as tube cleaning, boiler cleaning, repairs to settings, stoker and blower equipment.

He will see that all men under him conform to the license laws of the city and state before working under him, and that all casualty and insurance laws relating to the apparatus and men under him are complied with.

He will comply with the General Instruction from the General Manager's office as to the handling of his help.

Signed,.....
Maintenance Engineer.

....., 192.... Instruction No. ....

MAINTENANCE DEPARTMENT—ELECTRICAL ENGINEER

The electrical engineer will report direct to the Maintenance Engineer.

He will have charge of the electricians, elevator men, inspectors and helpers of his unit.

He will have charge of all electrical transmission lines from the busbars in the engine room to all other parts of the works, including the boiler room.

He will have the direction of the departmental help in the care of motors and lighting fixtures.

He will have supervision of all lines up to the starting boxes of motors and panel boxes of lighting systems, including the boxes.

He shall maintain all electrical apparatus on the switchboard in the engine room, leaving the operation to the switchboard men.

He shall operate and maintain all transformers in the works, including the service transformers.

He shall have charge of the operation and maintenance of all electrical apparatus in the works such as recording systems, time clocks, bell and call systems, elevator motors, etc.

He will inspect all electrical machinery used for generation or motive power.

He will inspect all parts of elevator machinery or hoists, including guides and cables.

He will make regular reports on proper forms of these inspections and turn them in to the office of the Maintenance Engineer.

He will direct the securing of data from the recording instruments in his unit for compilation in the daily report made up by the record clerk under the assistant engineer in the Maintenance Engineer's office.

He will see that all men under him conform to the license laws of the city and state before working under him and that all casualty and insurance laws as relate to the apparatus and men under him are complied with.

He shall perform work in the departments of the works only on plant equipment requisition as outlined in Method of Handling Plant Orders instruction from the General Manager.

He will comply with the General Instruction from the General Manager's office as to the handling of his help.

Signed,.....
Maintenance Engineer.

....., 192.... Instruction No.....

MAINTENANCE DEPARTMENT—FOREMAN MILLWRIGHT

The foreman millwright will report direct to the Maintenance Engineer.

He will have charge of the millwrights in this unit.

He will have charge of ironworkers in his unit.

REQ. Nº_____

MAINTENANCE DEPARTMENT

PLANT ORDER Nº _____

PLEASE ISSUE ORDER FOR DOING THE FOLLOWING WORK

ESTIMATED

Nº OF HOURS_____

Nº OF MEN _____

APPROVED

_____

	ENGINEER'S ESTIMATE	ACTUAL COST
ESTIMATED LABOR COST		
ESTIMATED MATERIAL COST		
TOTAL L. & M. COST		

DATE _____

_____ ENG.

SUBMITTED

PLANT EQUIPMENT REQ.

REQ. Nº_____ _____ DEPT. PLANT ORDER Nº _____

MR._____

THE FOLLOWING ARE THE DETAILS FOR YOUR DEPT. ON THE ABOVE ORDER Nº:

DATE _____

_____ MAINTENANCE ENGINEER

PLANT ORDER DETAIL SHEET

REQ. Nº _____ PLANT ORDER Nº _____

DELIVER TO		DESCRIPTION	QUAN	UNIT PRICE	UNIT	TOTAL

He will maintain all existing lineshafts and counters from lineshaft or motors to counters.

He will direct the cleaning and oiling of lineshafts and counters.

He will repair and tend all belting on a general order.

He will reset machine tools and other machinery on plant equipment requisition signed by the Maintenance Engineer.

He will set up new machinery on plant-equipment requisition signed by the Maintenance Engineer.

He will see that all casualty and insurance laws as relate to the apparatus and duties of the men under him are complied with.

He will perform work in the departments of the works only on plant equipment requisition as outlined in Method of Handling Plant Orders instruction from the General Manager.

He will comply with the General Instruction from the General Manager's office as to the handling of his help.

Signed,.....
Maintenance Engineer.

....., 192.... Instruction No. ....

MAINTENANCE DEPARTMENT—FOREMAN MACHINIST

The foreman machinist will report direct to the Maintenance Engineer.

He will have charge of the tinsmiths of this unit.

He will have complete charge of the repair of all power-plant equipment.

He will assist the departmental machinists when necessary in the repair of equipment or machine tools doing such work on plant-equipment requisitions.

He will install new power-plant machinery.

He will assist the millwright, plumber, steamfitter, tinsmith or other maintenance department foremen in completing plant-equipment requisitions when necessary.

He will conform to all casualty and insurance laws as relate to his men and equipment.

He will be guided in his work by the Handling Plant Orders instruction from the General Manager.

He will comply with the General Instruction from the General Manager's office as to the handling of help.

Signed,.....
Maintenance Engineer.

....., 192.... Instruction No. ....

MAINTENANCE DEPARTMENT—FOREMAN STEAMFITTER

The Foreman Steamfitter will report direct to the Maintenance Engineer.

He will have charge of the steamfitters of this unit.

He will maintain all steam fittings and pipe in the plant.

He will maintain all air, gas and oil piping in the power plant and works.

He will maintain all steam-heating distributing lines and returns in the whole works.

He will install new equipment for steam, air, gas and oil distribution or returns.

He will assist other foremen of the Maintenance Department in completing plant-equipment requisitions.

He will conform to all casualty and insurance laws as relate to his men and equipment.

He will be guided in his work by the Handling Plant Orders instruction from the General Manager.

He will comply with the General Instruction from the General Manager's office as to the handling of help.

Signed,.....
Maintenance Engineer.

....., 192.... Instruction No. ....

MAINTENANCE DEPARTMENT—ASSISTANT ENGINEER

The Assistant Engineer will report direct to the Maintenance Engineer.

He will head the fire department of the works.

He will be secretary of the Safety-First Committee.

He will act as or have charge of the record clerk.

He will be conversant with the insurance laws relating to fire protection.

He will train the fire-fighting organization of the works and conduct periodic fire drills.

He will prepare and keep up to date a chart of the fire department of the works, giving names of those in the organization and department of the works they are in.

He will preside at meetings of the Safety First Committee as representative of the Maintenance Engineer.

He will keep all records of the Safety First Committee.

He will issue calls at the direction of the Maintenance Engineer for meetings of the Safety First Committee.

He will direct the work of other foremen in the placing of guards in accordance with safety-first requirements.

He will receive and bring to the attention of the Maintenance Engineer all reports of the safety-first inspectors.

He will collect all data from the engineers for compiling the Daily Report.

He will make up the Daily Reports and file copies and see that copies reach the Maintenance Engineer.

He will make up from his Daily Reports the Monthly Analysis of these reports and forward one copy to the General Manager and keep one in the file of the Maintenance Engineer.

He will make up charts covering the calculations of the Daily Reports from day to day.

He will keep all records of the office of the Maintenance Engineer.

He will prepare and file all location plans of power plant, steam, water, oil, gas, sewer and air systems.

Signed, ...
Maintenance Engineer.

.....,192.... Instruction No. ....

MAINTENANCE DEPARTMENT—STOREKEEPER

The Storekeeper shall report direct to the Maintenance Engineer.

He shall have charge of stores in this unit.

He shall issue stores only on written order.

He shall receive stores only on proper authority.

He shall account for stores received, issued and on hand on regular forms provided him and make his accounting at regular intervals or on order of the Maintenance Engineer.

Signed, ...
Maintenance Engineer.

Similar instructions should be issued covering the duties of the foreman plumber, the foreman tinsmith, foreman carpenter, foreman mason, foreman painter, foreman of labor and foreman of the guards. With each copy of these instructions to foremen and engineers of the maintenance department should go a copy of the following from the office of the general manager and signed by him.

....., 192.... Instruction No. ....

MAINTENANCE DEPARTMENT—GENERAL INSTRUCTION

This instruction is issued to each foreman or engineer in charge of men in the Maintenance Department.

You will request additions to your working force through the employment department. This request shall be in writing and signed by the foreman requesting and have the written approval of the Maintenance Engineer. After the employment department secures a man for a foreman, the foreman will sign the Hire card and the Workman's Identification Card.

If you wish men from other departments for any reason, you will secure the transfer through the employment department who will send you such labor with a Workmen's Transfer Card (Form ....). You will not receive such men unless the transfer is signed by the department foreman transferring the man or men to you, and the same must have the written approval of the employment department and Maintenance Engineer. After receiving such labor from another department, you will sign the transfer card as the department foreman receiving the same.

When you discharge men or they are leaving of their own accord, you will send them to the employment department to have the Workman's Release Card filled out. This card shall be signed by the foreman releasing the man.

You will keep a complete list of employees under you.

This shall be on the form List of Employees. You shall keep a copy of this list and a copy shall be sent to the office of the Maintenance Engineer. This list shall be kept up-to-date at all times.

You will certify to each of your men's time on their time cards. Copies of these forms are attached.

Signed,.....
General Manager.

With the instructions to the foreman of the maintenance department should go the following, which should also be issued to the head of each department in the works.

....., 192.... Instruction No. ....

MAINTENANCE DEPARTMENT—METHOD OF HANDLING PLANT ORDERS

Plant Equipment Requisitions are to be used by all departmental heads and others in requesting work to be done by the Maintenance Department.

1. The request is to be made on the upper half of the form and signed on the top half by the person requesting the work. The request is then sent to the office of the Maintenance Engineer.

2. The Maintenance Engineer first signifies the nature of the proposed work called for by his first disposal of the request.

a. If it comes under a general or blanket order in his department, he will at once place it in the hands of the foreman or foremen to do the work, with his signature only.

b. If it appears to be work including an expenditure of more than called for in a general order, he will proceed to collect all data necessary for estimating the cost of the proposed job before submitting to the General Manager for final approval.

3. The Maintenance Engineer will have a complete study of the proposed work made.

a. He will have sketches or drawings made that will show the complete job.

b. He will then consult all foremen who are to do the proposed work as to material and men hours needed.

c. He will then have the Bill of Material made out and sent to the Material Department for estimate.

d. With the estimate of the material department totaled and the memorandum of the foremen on the required time, he will fill out the Estimated Labor Cost and Estimated Material Cost together with the estimate of the probable time necessary for the work.

e. He will fill out the lower half of the plant-equipment requisition with the above data, date the form and sign it as the one submitting the estimate.

f. He will then submit the request and estimate to the General Manager with all drawings or sketches going with the estimate and a written description of same for the final approval. The signature of the General Manager is authority for Maintenance Engineer to issue Plant Orders.

4. On final approval the Maintenance Engineer will then assign the Plant Order number and requisition number.

5. The Maintenance Engineer will then fill out the Detail Sheet for the guidance of the foremen doing the work and assign the plant-order number to correspond with the one on the plant-equipment requistion and bill of material.

The Detail Sheet must be made out clearly and be accompanied by sketches and drawings if necessary. They should be made out in a manner that will make them an explicit set of directions for the workman. They should describe the location and extent of the work contemplated so that it can be found by anyone who wishes to carry on the work or find it for inspection. A detail with the same requisition number should be made out for each foreman on the work and consecutive plant order numbers be given to the work in the order it is to be executed.

6. The Bill of Material will now be sent to the stores or purchasing department to be filled or ordered. A copy of the Bill of Material must go to the foreman who is to receive the same, and a copy kept on file in the office of the Maintenance Engineer.

7. When material is ready the Detail Sheets and Bill of Material copy with necessary drawings or sketches will be issued to the foremen to do the work.

8. The Maintenance Engineer will sign all the Detail Sheets issued, and his signature on them is the authority of the foremen to proceed with the work.

9. The Stores Department will issue stores on authority of the Bill of Material to the foremen presenting same.

10. Bills of Material must be made out clearly so that the description of the material will give every item of information required by the purchasing department, stores department or manufacturer from whom material is to be ordered.

11. Stores issued must be charged off to the proper requisition number.

12. The foremen will render an account to the record clerk in the Maintenance Engineer's office of all material and labor used on each requisition number.

13. The record clerk will make report to the accounting department of all material and labor used on requisitions.

14. The foremen will report to the Maintenance Engineer the start and completion of each plant Order on requisition.

15. On completion of Plant Orders on Requisition the Maintenance Engineer will send to the accounting department for a complete accounting of the cost of labor and material on each job on requisition and enter said amounts on the original Plant Equipment Requisition for record and comparison with the estimates.

16. General or blanket orders are to be issued under a given plant order number to cover all routine work such as repairs to toilets, cleaning drains, or such work that comes to this department or can cover all jobs not amounting to more than $50 in material and labor.

Signed,.....
General Manager.

PLAN ADAPTABLE TO ORGANIZATION OF ANY SIZE

The plan of maintenance department organization given here is one that is now in use in several factory organizations with slight variations to fit existing conditions. This plan can be made to fit in with any other plan of factory organization in use or can be made to fit the new organization of a maintenance department where there is no other correlating one.

The general manager in some organizations does not take the responsibility of the factory organization, leaving it to a works manager or superintendent. In this event one of the latter will issue the instructions to the maintenance department.

Again, the title of maintenance engineer does not cover the selection in this position. He may be works engineer or plant engineer to suit existing heads at the time of organization. The titles given in this plan are acceptable in the majority of cases.

The organization chart here given will cover power plants of from 5,000 to 10,000 b.hp. It can be trimmed to suit smaller plants and can be amplified to suit larger ones.

In this illustration the maintenance engineer is also chief engineer of the power plan. In a larger plant he might need an assistant in charge as chief engineer or master mechanic.

The power plant used as an illustration has stoker equipment and coal- and ash-handling apparatus, while the steam-generator sets are mostly turbine units.

Nozzle Design for Diesel Engines—Influence of Air Pressure and Engine Speed

By J. A. WALLARD

THERE are two reasons for using air to inject the fuel in a Diesel engine—first, to atomize it, and second, to carry it into the combustion space, distributing it as evenly as possible. The degree of atomization and the completeness of distribution can be controlled to a certain extent by the injection-air pressure, together with the location and size of the outlet nozzles on the injection valve. If the area through the injection valve can be made small enough and the shape of the combustion chamber is such that no special distribution is necessary, then no restricting nozzle plate will be required at the valve outlet. Indeed, there are many Diesel engines in operation today, notably of the heavy-duty, slow-speed marine type, which have inwardly opening valves and hence of necessity must depend on the valve area for control of the injection. In this case distribution is aided by the type of valve used, such as shown in Fig. 1, and the low speed of revolution is a very important factor in the right direction. In most cases, however, the design dictates the use of a valve with relatively large areas and a controlling nozzle on the outlet, as typified in Fig. 2. One of the problems, then, is the determination of the size of this nozzle, and to do this we must study the various factors that enter into the case. The size of any nozzle is a function of quantity, time and difference of pressure. In calculating the size, maximum conditions must be used and the minimum conditions cared for in some other way.

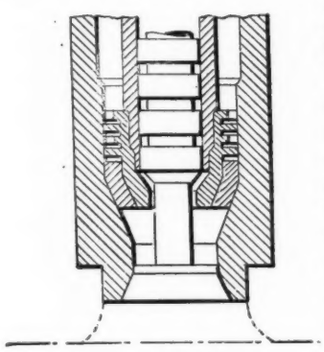


FIG. 1. INWARD-OPENING FUEL VALVE

Quantity of Fuel Consumed

The quantity item includes the fuel oil and the injection air. The quantity of fuel oil is directly proportional to the fuel consumption and the overload horsepower developed in the cylinder, and is inversely proportional to the revolutions per minute. Expressing this in another way, the quantity of fuel per stroke is equal to the total fuel consumed per minute divided by the number of working strokes.

But the fuel consumption per horsepower is, within reasonable limits, a constant for all types and sizes so that for our purposes we can say that $Q = A \times \frac{horsepower}{working\ strokes\ per\ min.}$ where Q represents quantity per stroke and A some constant. The volume of injection air used is a more or less fixed percentage of the piston displacement; but piston displacement is proportional to horsepower, and hence the quantity of injection air per working stroke is measured by exactly the same form of equation as was obtained for the fuel.

The time element is a function of valve opening measured in degrees and revolutions per minute. It is usual to keep the injection valve open for about a tenth of a stroke under maximum conditions, and hence the form of equation for time becomes

$$\frac{B\ angle\ of\ opening}{360\ degrees} \times \frac{1}{RPM} = \frac{C}{RPM}\ constants.$$

The third item to be considered, the difference in pressure between the injection air and the cylinder pressure, may be taken as a constant for present purposes in the development of a formula. The final result must always be checked by actual test, because no formula can take into account every variation in a new size or design, and what is really wanted is a good approximate guide. Combining all this, we have the following relation:

$$Area\ of\ nozzle = A \frac{horsepower}{working\ strokes\ per\ min.} \times \frac{C}{RPM}.$$

Constants for Two- and Four-Stroke Cycle Engine

An inspection of this equation shows at once that if we wish to reduce things to the simplest terms, we shall have to use separate expressions for two-stroke-cycle engines and four-stroke-cycle engines, because in a two-stroke cycle every revolution brings a working stroke while in a four-stroke cycle it is only every other revolution. The two expressions will have exactly the same form, but different constants will be used. To simplify still further, let us remember that the area of the nozzle is proportional to the diameter squared and that horsepower in an oil engine generally means brake horsepower. Hence

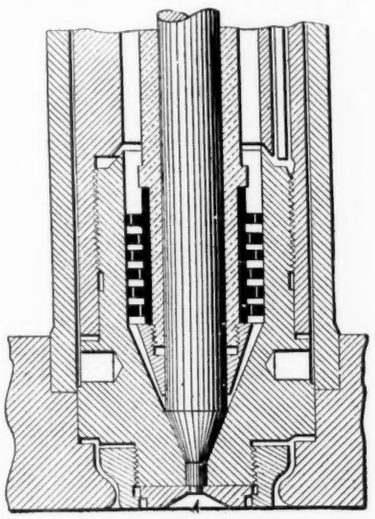


FIG. 2. FUEL VALVE WITH NOZZLE

$$d = \frac{BHP}{F}\ for\ four\text{-}stroke\text{-}cycle\ engines,\ \text{and}$$

$$d = \frac{BHP}{T}\ for\ two\text{-}stroke\text{-}cycle\ engines,$$

where d is the nozzle diameter in inches and F and T are constants. It remains therefore to determine the values of F and T, and this can best be done by taking some actual examples from engines already built. Some examples available show values of $F = 45$ and $T = 65$ as good average figures, but individual examples show considerable variations from these figures, due to certain conditions peculiar to the individual engine.

As already pointed out, the nozzle sizes obtained by the expressions just given are only approximate and careful tests alone can determine finally the very best sizes.

In deriving the formulas, the difference between injection-air pressure and cylinder pressure was taken as a constant in order to simplify the equation. This holds perfectly true for similar types of engines, but is not true for such widely different types as a high-speed submarine engine and a low-speed heavy-duty stationary or merchant-marine engine. Both types use about the same cylinder compresson pressure (about 475 lb. per sq.in.), but the combustion pressure in the high-speed engine rises to perhaps 550 or even 600 lb. per sq.in., while in the heavy-duty engines it is only 500 lb. or even no more than the compression pressure. The best injection-air pressures are found to be from 1,000 to even 1,200 lb. per sq.in. for the high-speed engines and generally about 800 lb. per sq.in. for the low-speed engines. These differences are due to the conditions of working. From the high-speed engine the highest possible power output for a given piston displacement is desired, while in the case of the low-speed engine, reliability and economy are the main objects sought.

Injection Air Pressure

In any case the lowest possible injection-air pressure that will give the results wanted is the best. The lower the pressure, the easier the duty on the air compressor and the less the chilling effect on the combustion in the cylinder, due to the expansion of the air. With a new type of engine the best method to be pursued is to run a series of tests with gradually increasing sizes of nozzles and varying injection pressures with each nozzle. A point will soon be found where increased size brings no advantage, and that size with the proper injection pressure is the one to be adopted.

So far the discussion has been confined to a single-hole injection nozzle, but oftentimes, in order to get a proper distribution of fuel throughout the combustion chamber, it is necessary to use a multihole nozzle. For this latter type the procedure up to this point is exactly the same as for the single-hole nozzle and all the foregoing remarks apply with just as much force. Therefore, to design a multihole nozzle, divide up the combustion-chamber volume into such size volumes as are consistent with the proposed number and direction of small nozzle holes, then make the size of each hole in proportion to its volume of the combustion chamber and the total area of the holes equal to the area of the single hole found in the regular way. Unfortunately, the cut-and-try method has to be used here too, but one or two trials will generally show the best lead and the final result is quickly obtained.

Effect of Engine Speed

Speed of revolution has a very important influence as to when to use a multihole nozzle and when to use a single nozzle. The writer has a case in mind of two engines with the same size of cylinder and similarly shaped combustion chambers in every way, but one engine turns at about 250 r.p.m. and the other at about 400 r.p.m. A multihole nozzle is absolutely necessary in order to get the best results in the higher-speed engine, but the lower-speed engine acts exactly the same whether a single or multihole nozzle is used. In other words, the time element is longer in the low-speed engine, and thorough distribution is not so vital.

This time element is very important, and it is so bound up with effective atomization and distribution that it deserves extra attention. To bring the point out sharply, let us take the case of the high-speed engine and note the differences between the results at full speed and at reduced speed, so that the conditions will be as nearly as possible exactly the same except for the time element. In such an engine of the four-stroke-cycle type the revolutions per minute will vary from 380 to 450 at full speed, depending on the size of the engine, and the piston speed will be 1,200 ft. per min. or more. If we take 420 r.p.m to represent average conditions, the time that the spray valve is open amounts to about $\frac{60}{420} \times \frac{45}{360} = \frac{1}{56}$ seconds, and for best results the combustion ought to be completed within that time. Of course we know that it is not and that combustion during the expansion stroke occurs even on low-speed engines. Now let this engine slow down to, say, two-thirds speed, when the piston speed will become about 800 ft. per min. and the time of opening of the spray valve will be actually 50 per cent longer, or about $\frac{1}{37}$ second. In other words, the time for combustion under the best of conditions has been increased 50 per cent. It will be found that with the power reduced in proportion to the revolutions—that is to say, if the same mean effective pressure prevails in both cases—the fuel consumption per horsepower will be over 10 per cent less at the lower speed. It might be argued that better atomization and distribution at the higher speed would reduce this difference, and this is entirely possible, but the condition just mentioned is the present state of the art and only extensive experimental work would determine the possibilities for improvement. An indication may be obtained, however, from the fact that the same characteristics are shown by engines with one spray valve and engines with two spray valves, and with different designs of combustion chambers. Also, it is interesting to note that it has been stated that the German submarine engines were fitted with two spray valves primarily to help the cylinder-head design and not to aid combustion. It is no phenomenon peculiar to high-speed engines either, but runs through all sizes and varieties. The high-speed engine feels the effect worse, of course, and was chosen in this example in order to bring out the point more distinctly.

Effect of Variable Load and Speed

As was stated in the beginning, the nozzle must be designed for full-load and full-speed conditions, but the condition of varying load and full speed existing in a stationary engine and the condition of reduced load and speed in the case of the marine engine must be provided for. With the stationary engine there is no question of air-compressor capacity because the consumption decreases as the injection-air pressure is decreased to suit the reduction in load. It is, therefore, a question of the best pressure for a given load, and with the usual injection-valve arrangement of constant time of opening the matter is squarely up to the operator to get the best result possible. There are certain broad principles that apply to all cases, and it is a simple matter to determine when the best results are being obtained.

At full power the engine will run with a wide variation in injection-air pressure and the economy will not be badly upset unless an extreme pressure is used; but for light loads the available range of pressure is very short

because too great a pressure will give such a chilling effect that the temperature in the immediate vicinity of the fuel blast will be lowered to the point where no ignition will result, and too low a pressure will atomize the fuel. In fact, with a very low pressure there is danger of burning the spray-valve seat or even doing more serious damage. It is, therefore, never advisable to drop the injection-air pressure below 550 to 660 lb. per sq.in. under any circumstances. The available range of pressure at the low end of the scale is perhaps 50 to 100 lb. per sq.in. For full-load conditions, if the very best pressure is, say, 850 lb., acceptable pressures would probably range from 825 to 900 lb. The economy is more seriously affected by a reduction in pressure than by an increase.

In order to overcome some of the difficulties just mentioned, certain engine builders arrange to have one-half of the cylinders cut out at very light loads. This increases the load on the other cylinders enough to give regular ignitions and not only is the engine less sensitive to a variation in spray-air pressure, but incidentally greater accuracy of governing is secured. Some builders even go a step farther and vary the spray-valve lift with the load, which practically eliminates any sensitiveness due to injection-air pressure variations. Under these conditions there is little difference between the best pressure at full load and at light load, but this is under the control of the governor and does not need to worry the operator.

Marine Diesel Air Pressures

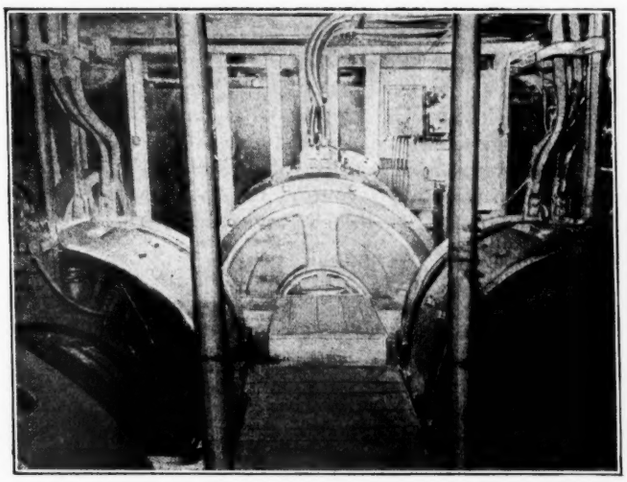
The marine engine case presents greater difficulties than the stationary since the propulsion power decreases approximately as the cube of the ship's speed and the revolutions only directly. It is customary to fit rather large air compressors in order to have a surplus capacity for refilling the starting-air tanks and also to provide a margin for reduced-speed running. As the speed is reduced, the total time that the spray valves are open during a second or a minute is the same, and consequently with the same air pressure the air consumption is constant in spite of the reduction in speed. The reduced air pressure which is used reduces the consumption to a certain extent, but since the production is only directly proportional to the speed of revolution, a point is reached at from one-third to one-half speed where the supply fails to keep up with the demand. By this time the power required has also dropped to such an extent that ignition troubles begin, so that this becomes the lower operating limit for practical purposes with constant time of opening injection valves. With special care and a skilled operator this limit can be lowered, but under ordinary conditions one-third speed is about the limit. In most cases this is no disadvantage whatever since the full speed is generally ten to twelve knots and one-third of these speeds is barely steerageway. To express it in another way, a marine engine operates at nearly full power and speed most of the time, and provided it can be slowed down on occasion and can be maneuvered satisfactorily, all requirements will be met.

The simplest method of determining the best injection-air pressure is to watch the exhaust temperature. Without a doubt, the exhaust-temperature thermometer is one of the most important instruments used around an oil engine, because no matter what happens to upset the combustion, the result is immediately registered on the thermometer. The operator may need all sorts of instruments and special tests to locate the trouble, but the exhaust temperature, if watched and compared, never fails to give a warning when something is wrong with the combustion. Consequently, the way to find the best injection-air pressure for a given set of conditions is to vary the pressure and watch the thermometer. When it registers the lowest, record the pressure for future reference and use; once determined, it will always hold until some condition is changed. The whole procedure is so simple that there is no excuse for an operator not knowing the best pressure for any condition. It would be sufficiently important if it were only a question of economy, but it means reliability as well. Poor combustion and the resultant high exhaust temperature invite trouble all around.

The Diesel-Electric Trawler "Mariner"

The propelling equipment comprises two eight-cylinder four-cycle 350-r.p.m. Nelseco-Diesel engines, each direct-connected to a 165-kw. 125-volt, G. E. direct-current generator. The two self-excited generators are normally connected in series and supply current to a 400-hp. 250-volt, 200-r.p.m. motor, which is direct-coupled to the propeller shaft.

The 400-hp. propeller motor is located forward of the generating sets and has a normal full-load speed range



ENGINE ROOM (LOOKING FORWARD), SHOWING MAIN GENERATORS AND PROPELLER MOTOR, WITH MASTER CONTROLLER AT RIGHT

of from 160 to 200 r.p.m. It is a compound-wound machine, and when taking current from both generators, it operates at 250 volts; but for slow cruising one engine can be shut down and the motor then receives current at 125 volts. Under these conditions it has a speed range of from 70 to 160 r.p.m.

The fishing operations are carried on by means of a 65-hp. motor-driven, main double-drum hoist, installed on the main deck forward of the engine room, which handles the haulage cables and ropes of the net as they pass through the hoist brackets fore and aft on either side. The unloading of the fish at the dock is accomplished by means of a 5-hp. motor-driven whip hoist located near the forward mast.

The Engineer states that according to reports received from Germany, steel suitable for the valves of oil engines is being made containing 0.33 per cent carbon, 0.46 manganese, 0.45 silicon, 0.03 sulphur, 0.75 phosphorus and 11.02 chromium.

Investigation of Gas-Fired Steam Plant

A Study in Operating Efficiencies and Control Methods in a 48,000-Sq. Ft. Boiler Plant Using Coke Oven Gas as Fuel—Results Show CO_2 Flue Gas Content a Reliable Efficiency Indicator, and Excess Air Not a Requisite for Practically Complete Combustion

BY R. L. ELLIS

THE plant investigated was that of the Sloss Sheffield Steel and Iron Co. at North Birmingham, Ala., engineered and built by the Semet Solvay Company. The steam plant consists of eight 6,000-sq.ft. Stirling boilers with superheaters designed for 150 deg. superheat. All are connected into a common header with the usual non-return and cutoff valves between the boilers and header, which is provided with sectionalizing valves. Six boilers are gas-fired, using Birkholtz-Terbeck burners, eight to the boiler, and two are arranged to burn coal braise on Coxe stokers. The gas-fired boilers are arranged in groups of two so far as connections to gas main is concerned, so that each group can be shut off and gas pipes and mains repaired without interference with the operation of the plant. The stoker-fired boilers are provided with coke- and ash-handling equipment, coke bunkers, etc.

Feed water in the raw state runs about 20 parts per 100,000 in solids, mostly lime and magnesium bi-carbonates. The water is treated with lime and soda ash, using Sorge-Cochrane apparatus with extra-large sedimentation tank. Water is fed to boilers by a centrifugal pump through a venturi meter. There are three feed-water pumps installed, two turbine-driven and one motor-driven.

Gas is fed to the boilers through a venturi meter. Steam is delivered to the header through flow meters —combined indicating, recording and integrating. Recording thermometers are provided for feed water just beyond the heater in the feed-water header in front of the boilers, and for the steam in the main header. Recording gages are provided for steam pressure in the header, water pressure in the header and gas pressure in the gas main. The CO_2 in flue gases is recorded by Foxboro-Heath recorders.

The object of the investigation was to determine just what efficiency of operation might reasonably be expected to be maintained, and to institute control methods to assist in maintaining the most efficient operation. In making the investigation the method was to determine what might be expected and to devise methods to maintain the efficiency and check the calculations by tests. In making the tests, commercial accuracy only was attempted, methods of precision not being used as conditions did not seem to warrant the effort.

An analysis of the gas used is made daily so that an average over several months was available, as follows:

	Volume, per Cent	Weight, per Cent
CO	4.2	11.10
H_2	53.1	10.15
CH_4	32.2	49.26
C_2H_4	1.6	4.24
O_2	0.2	0.60
CO_2	1.0	4.19
N_2	7.7	20.46
	100.0	100.00

Moisture in gas 30 gr. per cu.ft., 1,020 per pound.
B.t.u —Calculated, 535; by calorimeter, 530 per cu.ft. 18,090 per pound.
Weight per cu.ft. 0.0294 by calculation.
Specific gravity by calculation 0.39; by measurement 0.38.

In making the predetermination of losses it was necessary to determine: (1) The relationship of CO_2 in the flue gases to excess air supplied to the gas for combustion; (2) the relationship of O_2 in the flue gases to excess air supplied to the gas for combustion; (3) the relationship of boiler efficiency to the CO_2 content in the dry flue gases; (4) the total hydrogen in the fuel gas; (5) the total carbon in the fuel gas; (6) the weight of dry flue gases in relation to excess air supplied to the gas for combustion; (7) the relationship between gas and air for perfect combustion.

Items 1 and 7:

PRODUCTS OF COMBUSTION

	% in Gas	Required for Comp. Comb. O_2	Required for Comp. Comb. Air	One Volume CO_2	One Volume H_2O	One Volume N_2	Actual Gas Used CO_2	Actual Gas Used H_2O	Actual Gas Used N_2
CO	4.2	0.5	2.391	1.0	...	1.891	4.2	...	7.9422
H_2	53.1	0.5	2.391	...	1.0	1.891	....	53.1	100.4121
CH_4	32.2	2.0	9.564	1.0	2.0	7.564	32.2	64.4	243.5608
C_2H_4	1.6	3.0	14.346	2.0	2.0	11.346	3.2	3.2	18.1536
O_2	0.2	...	.....	...	...	.....	....	....	.....
CO_2	1.0	...	.....	1.0	...	.....	1.0	....	.....
N_2	7.7	...	.....	...	...	1.000	....	.....	7.7000
	100.0	..	.....	...	...	....	40.6	120.7	377.7687
									40.6
									418.3687

40.6 ÷ 418.37 = 9.7%

Or, otherwise stated, with perfect combustion there is a possibility of 9.7 per cent CO_2 content in flue gases.

Item 6:

CO	4.2 × 2.391 =	10.0422
H_2	53.1 × 2.391 =	126.9621
CH_4	32.2 × 9.564 =	307.9608
C_2H_2	1.6 × 14.346 =	22.9536
		467.9187

Or one volume of gas requires for complete combustion 4.68 volumes of air.

Therefore each volume of gas burned will require for complete combustion 0.98 volume oxygen and 3.7 volumes nitrogen.

Item 2:

One volume of gas perfectly united with 4.68 volumes of air will produce in flue gases,

CO	0.406	9.7%
O_2	0.000	0.00
N_2	3.777	90.3

And by adding 20 per cent, 40 per cent, 60 per cent, 80 per cent and 100 per cent of excess air, the flue gases will contain

	20%	40%	60%	80%	100% excess air
CO_2	7.9	6.7	5.8	5.1	4.5
O_2	3.8	6.4	8.4	9.9	11.1
N_2	88.3	86.9	85.8	85.0	84.4

Item 4:

The total hydrogen (wt.) is equal to $H_2 + \frac{1}{4} CH_4 + \frac{1}{7} C_2H_4 = 0.2307$ lb. per lb. gas.

Item 5:

The total carbon (wt.) is equal to $\frac{3}{7} CO + \frac{3}{11} CO_2 + \frac{3}{4} CH_4 + \frac{6}{7} C_2H_4 = 0.4747$ lb. per lb. gas.

The losses occurring in the combustion of gas fuel are as follows: (1) loss due to moisture in gas; (2) loss due to combustion of hydrogen to H_2O; (3) loss due

to heat wasted in dry flue gases; (4) loss due to radiation; (5) loss due to moisture in air.

Loss 1:

The loss due to moisture in the gas is constant for any excess of air and is as follows:

$$Loss = \frac{1,020}{7,000} \times .48\ (475 - 72) = 28.24\ B.t.u. = 15\%$$

1,020 being the gr. moisture per lb. gas, 7,000 gr. per lb., 0.48 specific heat water vapor for temperature range, 475 average temperature flue gases and 72 temperature of gases at burner.

Loss 2:

Loss due to combustion of hydrogen to H_2O is constant for any excess of air and is as follows:

$$Loss = H_2 \times 9\ [(212 + 72) + 970.4 + 0.48\ (475 - 212)] = 2567.63$$
$$B.t.u. = 14.19\ per\ cent$$

9 being volumes water vapor, 212 temperature of water at boiling, 970.4 latent heat steam at 212 deg., and others as above.

Loss 3:

Loss due to heat wasted in dry flue gases, is variable with the amount of excess air and is as follows:

$$Loss = 12.47 \times 0.24\ (475 - 72) = 1206$$
$$B.t.u. = 6.66$$

12.47 being weight of air and gas per pound gas for complete combustion and 0.24 specific heat of gases for temperature range.

Losses 4 and 5:

Loss due to radiation is not directly calculable, and the loss due to moisture in gas is rather small, so these two are lumped together as a constant at 5 per cent.

Tabulating these losses we have,

1	0.15%
2	14.19
3	6.66
4 and 5	5.00
	26.00

Under item of "Loss Due to Heat in Flue Gases" we can assume excess air of, say, 20 per cent, 40 per cent, 60 per cent, 80 per cent, 100 per cent, and similarly calculate the loss under the changed conditions. If we then combine these losses, we will be able to ascertain the total losses for any excess of air supplied. By combining these figures we have,

Excess air, per cent.	0	20	40	60	80	100
Total loss, per cent.	26.00	27.23	28.45	29.68	30.90	32.13

And from the total losses we can determine the efficiency we should have with any excess of air.

From the calculated relationship between excess air and CO_2 we can construct a curve.

From the calculated relationship between excess air and O_2 we can construct a similar curve.

From the calculated relationship between excess air and the excess air-CO_2 curve we can construct an efficiency curve on a base of CO_2 content in flue gases and by these three curves establish definite procedure for operating the plant to maintain maximum practicable efficiency.

After control curves were worked out, several test runs were made and results calculated to ascertain just how close the results obtained would approximate the calculated results. These figures are the average of several days' run and are reduced to a basis of 24 hours. In making the test, arrangements were made with another power plant to take the variable load and allow the plant under test to operate at approximately constant load. This was in order to keep the CO_2 content in flue gases approximately constant and also relieve us of sufficient load so that it was not necessary to fire the stoker-fired boilers.

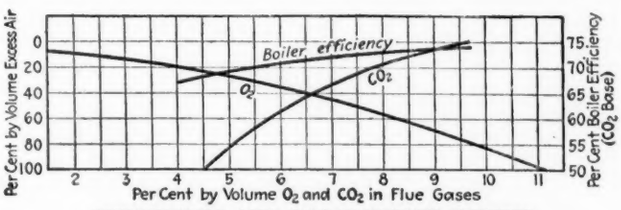
In running the test the following averages were maintained over a period of several days and average data used:

Boiler room temperature, deg. F.	70
Temperature of up take, deg.	475
Temperature of gas, deg.	110
Temperature of gas and air (taken as at burner—calculated), deg.	72
Temperature of feed water (taken at entrance to boiler), deg.	185
Superheat, deg.	120
Factor of evaporation	1.169
Heat value gas (dry), B.t.u. calorimeter = 18,090 lb.	530
Heat value gas (dry), B.t.u. from analysis	535
Total gas used Venturi meter, cu.ft.	7,365,400
Total steam integrating flow meters, lb.	2,511,600
Actual evaporation, lb. per cu.ft. gas	0.341
Equivalent from and at 212 deg., lb. per cu.ft. gas	0.3976
Total heat in 0.3976 lb. steam from and at 212 deg., B.t.u.	385.83
Heat value gas, B.t.u.	530
Efficiency, per cent.	72.8

Average analysis of flue gases (CO_2 maintained approximately constant and instantaneous samples taken at intervals for CO and O_2):

	Volume, per Cent	Weight, per Cent
CO	0.05	11.05
CO_2	7.75	11.61
O_2	3.75	4.08
N_2	88.45	84.26

From the curve this indicates about 20 per cent dilution or excess air. As a sampling tube placed in the second pass indicated that the excess air was due entirely to leakage, steps were taken to make the settings tighter, and after this was done we were able to get as high as 9 per cent CO_2 in flue gases, but conditions were then such that we were not able to operate without stoker-fired boilers, so no further tests were run.



EFFICIENCY AND GAS-CONTENT CURVES

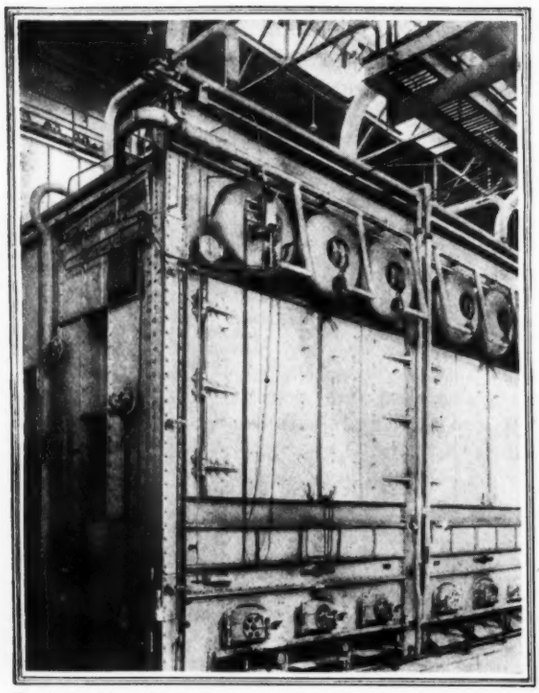
By calculation from "weight of air per lb. of gas fired," we obtained a figure of 14.66 lb. air and gas per pound of gas fired when using 20 per cent excess air.

Taking the flue-gas analysis as above and figuring the weight from the weight of dry products of combustion we get a figure of 15.84 lb. Similarly, from fuel-gas analysis we get, pounds carbon per pound gas fired, 0.4747, and from basis of products of combustion we get pounds carbon per pound, gas fired, 0.5052.

After checking the accuracy of control methods based on the foregoing calculations and curves drawn from them, automatic air and gas control was worked out operated from steam pressure. This was installed on one boiler and found so satisfactory that it was decided to install on the entire lot. This combined air-gas control automatically maintained the CO_2 content in flue gases within 0.5 per cent range.

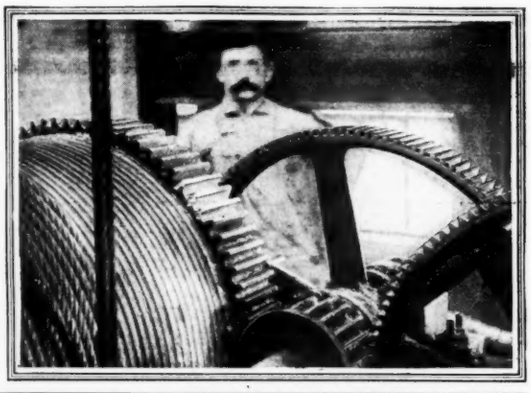
From the tests made it is evident that when using coke-oven gas for boiler fuel the CO_2 content in flue gases is a reliable indicator of the efficiency of operation, and that, with this as a basis, methods of control can be worked out which will be thoroughly reliable as a guide for operation.

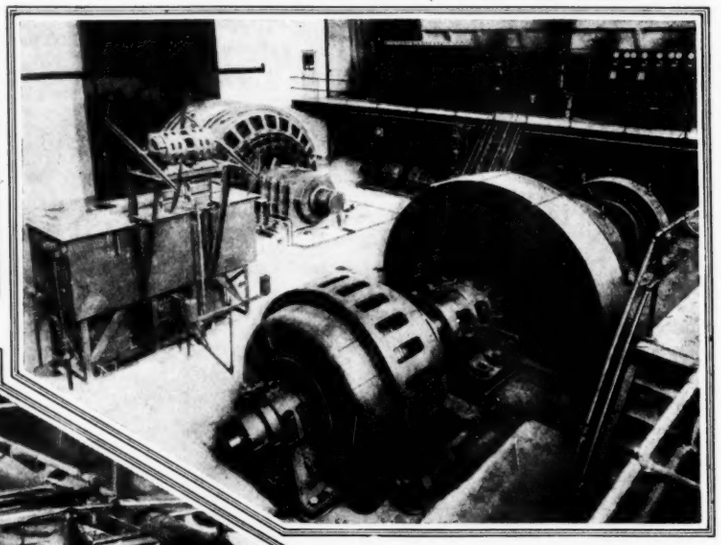
It is also evident that it is possible to operate boilers under similar conditions with no excess of air supplied to burners without material loss from incomplete combustion. This is contrary to generally accepted belief.

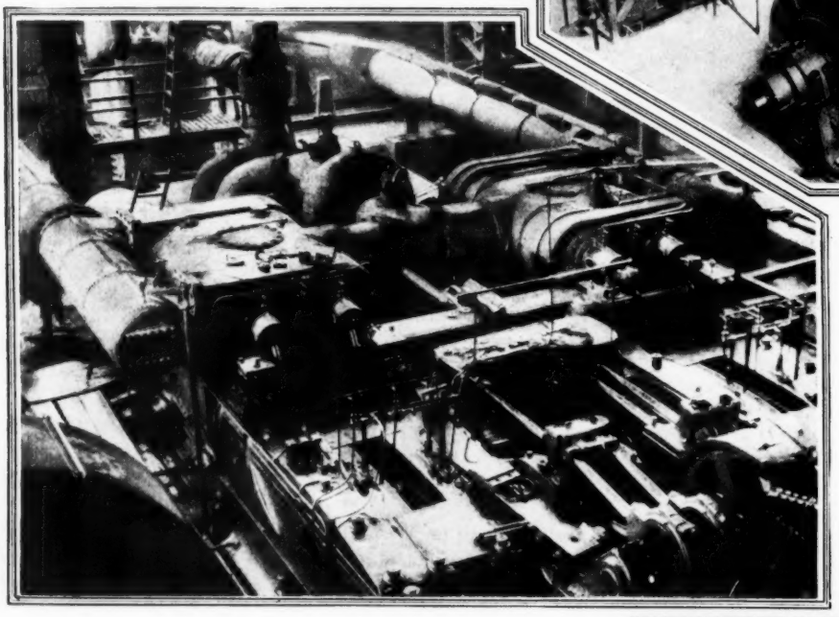


Typical oil burning boiler well equipped with instruments.

Several broken teeth in this large elevator drum gear and pinion were built up by oxy-acetylene welding and put back in service within 24 hours.





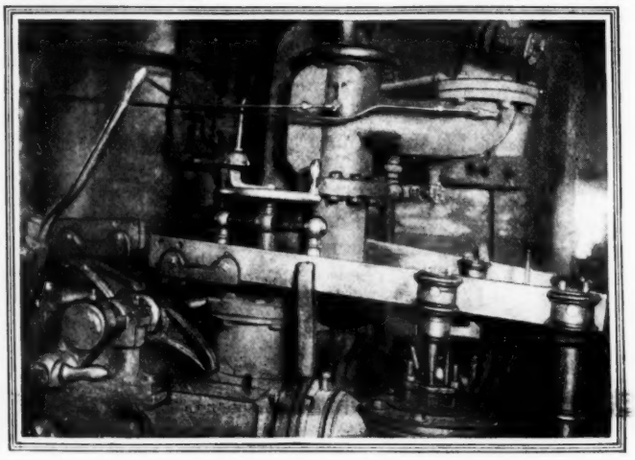


Left, a big twin tandem compound reversing steam engine, 36 and 60x54 inches, which drove a 44-in. blooming mill in the Steelton Plant of the Bethlehem Steel Co. It was replaced in only 24 days by the Westinghouse electric installation shown above. The latter consists of a 6,600 v., 3,200 hp. a.c. motor direct connected through an enclosed flywheel to two 600 v. 367 r.p.m., d.c. generators, and the main 600 v. motor.

Valve gear on a veteran 26x66 inch engine in the Ewald Iron Co.'s plant at Louisville, Ky. Installed in 1869, it has been in use ever since except for the time needed to rebore the cylinder once. It is of the old steamboat type, with a twenty-five ton flywheel and a wooden connecting rod.

Contributed by John F. Hurst.

Where the money goes in developing hydro-electric power. Building about thirty miles of roadway just to make possible transportation of machinery for a new power-plant in the High Sierras.



EDITORIALS

The Boiler Inspector's Position

THE National Board of Boiler and Pressure Vessel Inspectors at its recent meeting arranged to accept, in interstate work, the certificates of inspectors who have been examined and passed by the Board; to provide for a simple system of stamping and registering boilers and to approve specific designs and appliances.

Each of these is a service that would conduce to greater efficiency in this important branch of safety engineering; a service that, in the absence of the possibility of a Federal industrial inspection service, can be performed only by some such a voluntary organization.

The only doubt connected with the plan is concerned with the stability of the Board.

To be a safe repository of the records of the boilers of the country—a sort of registry of vital statistics for steam boilers—the Board must prove its own permanency and establishment. An organization the membership of which is constantly shifting, composed of individuals whose tenure of office depends not upon their efficiency but upon the turn of the political tide, can never attain to any great stability, can never develop any great authority or establish itself very firmly in the public confidence.

No other office in the civil service demands more urgently the experience that comes with continuity of service, the knowledge of principles and the acquirement of craftsmanship that come from devotion to a subject in the full confidence that it is to be one's life work.

An inspector body composed of units who have to work harder to keep their jobs than to find defects in boilers, whose mental energy is exhausted and whose attention is distracted by a continual jockeying to keep themselves or their party in power, will never develop any Fairbairns or Stromeyers.

The man at the head of a state boiler inspection department ought to be appointed because of special qualifications for the position. His work is not like that of an ordinary inspector. He must know how boilers are made, the ills to which they are subject, the characteristics of the materials of which they are composed, the manner in which they are affected by conditions to which they may be subjected in service. He should feel a personal responsibility for every serious accident to any boiler under his jurisdiction. It should be his ambition to reduce such accidents to the lowest possible terms. A national board composed of units like him, each fixed for life in a career the success of which meant "No More Boiler Explosions!" would become a national institution of influence and power based on actual service and certain to endure.

The man who does the actual inspection of the boilers under the direction of the state inspector must, of course, be a man of special qualifications. The appointing power does not always realize this, and boiler inspection is sometimes made a farce by the appointment of a barber or someone no better able to seek out the hidden faults and incipient failures of the magazines of energy which run our factories and lurk under the sidewalk and in the cellars of hotels and department stores. The fact that their appointees will have to pass the censorship of the National Board before their inspections will be accepted by other states will be a salutary influence upon the authorities charged with the selection of these men.

Steam-Turbine Lubrication

THE steam turbine, as now commercially built, is less than twenty years old, yet it has revolutionized power development and industrial development dependent upon power, more than any other prime mover. It is an example of specialization, for despite that it had its origin in antiquity, it is the effort of modern specialists in thermodynamics, metallurgy, machine-shop practice, power auxiliaries, etc., that is responsible for its rise to supremacy in a comparatively few years. Now comes development in the lubrication systems of such units, a work of specialists which is another important engineering step forward in steam-turbine operation. But consider the conditions of lubrication in a steam turbine before going into detail about this step.

The journal speeds are higher than in any other type of prime mover and in most, if not all, other machines. The bearing pressures are not extraordinarily great, but this is more than compensated for by the high journal speed. Bearing temperatures normally are high, 130 to 150 degrees Fahrenheit, and most units operate at temperatures around 150 to 180 degrees—some at 190 degrees. These temperatures, together with rapid circulation of the oil, are severe on the lubricant. In fact, steam-turbine lubrication is perhaps more severe on oils than any other kind of service. The lubricating systems of all large turbines, about seven hundred kilowatts and up, are pressure systems which have been commendably worked out by turbine designers.

It has long been generally recognized that the factor of safety with turbine lubricating oils should at all times be high on account of the great damage that would result should metallic friction exist at the journals of the heavy and fast rotating spindle; clearances, axial and longitudinal, are very small, and unbalancing of the spindle is always serious. The investment that a turbine represents requires a high factor of safety of the oil and the lubricating system.

Experience shows the need of a thorough system of oil purification for steam turbines if this high factor of safety and economy in the use of oil are to be had. Performance data gathered from the field disclose the rather surprising fact that oils in constant service over periods up to nearly three years are unimpaired in lubricating value when continuously purified.

This is surprising only on superficial consideration, for if the oiling system and the oil are clean in the beginning, and the water, and solids which cause emul-

sion, sludge, etc., are continuously removed as formed, these trouble makers, which promote the deterioration of an oil, are not present. Freedom from sludge keeps the oil-cooler surface clean of non-conducting deposits. Thus, the surface being ample and the cooling-water temperature normal, the oil and bearings do not reach the high temperatures which accelerate oxidation of the oil.

The continuous purification of turbine oil is a marked improvement upon merely adding makeup oil, sweetening and batch filtration. In the two former methods, widely practiced but a few years ago, the impurities, emulsion, sludge, etc., were merely diluted, not removed. The batch system of purification was an improvement over these, but continuous purification, being automatic, is a noteworthy step in a field where the service is most severe on the lubricant.

An Opportunity for Service

FOR years the engineering profession chafed under the lack of public appreciation of its accomplishments. This led to agitation within the engineering societies for action that would insure proper recognition, and for a while the society meetings were rife with discussion as to how the result might best be brought about. The matter had not passed the discussion stage when along came the war and afforded a real opportunity for engineering service. How engineers acquitted themselves in this task is too well known to call for further reference, and their work established engineering in the front rank of the professions. There remained only to provide the necessary machinery to perpetuate this prestige and make available for public service the special training of the engineer. The Federated American Engineering Societies was evolved from this ideal, representing, as it does, over fifty thousand engineers.

Under the leadership of Herbert Hoover, the American Engineering Council has selected as its first task a survey of industrial waste with a view to eradicating this most insidious of industrial ailments and thereby stabilize both business and labor. The Council has chosen the basic industries for its investigation and for the past two months has had forty field workers engaged in an intensive study. The final report will be based upon an analysis of their findings.

Without minimizing the importance of the investigation, it bears pointing out that the rendering of the report will mark only the beginning of the work; the supreme task will lie in putting the recommendations into effect. It is here that petty opinions and archaic practices will have to be met and overcome, and the manufacturer sold the idea of viewing industry not alone from the narrow standpoint of his own business, but with regard to its interrelation with other fields.

Fifteen months ago Mr. Hoover, in his inaugural address before American Institute of Mining and Metallurgical Engineers, outlined very clearly what was wrong with the coal industry and prescribed the remedies, yet nothing was done and we again experienced an acute fuel situation last winter. There was no agency to put the ideas into effect.

The Council hopes to accomplish much through publicity; but that is not enough—the active co-operation of engineers individually and collectively through local as well as national organizations will be necessary if the work is to succeed.

Hydraulic-Turbine Tests

FOR many years, it has been general practice in well-operated steam power plants to keep careful check on the operating performance of the various units. These checks are considered of such significance to efficient operation that no plant of any size or importance can afford to neglect them. However, in general no such code of operating practice has developed for the hydraulic power plant. One of the chief factors responsible for this has undoubtedly been the lack of some convenient and reliable means of measuring the input to the turbine. It is a well-known fact that turbines having high efficiency when first installed may fall down badly after being in service for only a short period, therefore careful check should be kept on their performance.

Power demands have increased far beyond the capacity of many of the hydraulic power sites and the difference has to be supplied from steam plants. Or other sites have been developed to their economical maximum to operate in parallel with steam plants. In some cases the amount of water available has been limited by treaty rights or other restrictions. In other developments large investments have been made in reservoirs to store water during flood periods so that it will be available for power purposes during dry seasons. In each of these cases water has a real value and the efficiency of the turbines becomes of primary importance, since every kilowatt-hour obtained from the water means increased revenue from this source. Therefore it is essential that some ready means be provided for accurately measuring the flow of water to the turbine so that its efficiency can be checked periodically.

There have been developed many methods for measuring the flow of water, such as the weir, venturi tube, the chemical method, etc. However, all these have their serious disadvantages when applied to large modern hydraulic power plants. Among these disadvantages are difficulty in application, loss of head through them, and excessive cost of installation. Moreover, some of them require correction factors upon which experts disagree, have possibilities of errors that may be overlooked unless used by a specialist, and also require that the unit be out of service for considerable periods during the tests.

There has been developed by N. R. Gibson, hydraulic engineer, of the Niagara Falls Power Company, a new method of measuring the flow of water in pipe lines, which gives promise, in point of accuracy, ease of application and limited expense, of filling the need for a measuring device to determine the input to hydraulic turbines, so seriously felt at this time. The method and apparatus are described in the leading article in this issue. Professor Joukovsky determined, by experiment at Moscow in 1898, that when the flow of water through a pipe line was stopped or partly arrested, the stored energy in the water due the moving mass was dissipated in the form of pressure waves. These waves are transmitted along the column of water in the pipe, similar to sound waves, and this is the fundamental principle of Mr. Gibson's new method and apparatus. He has provided a means of measuring and photographing these waves so as to obtain a permanent record, from which the flow of water may be determined. Volumetric tests show that the device is highly accurate. To apply it, all that is required is a small hole tapped in the side of the penstock.

CORRESPONDENCE

Tables of Physical Properties of Various Refrigerants and Steam

I note in the correspondence columns of the Jan. 18 issue of *Power* that C. F. Matthews, president of the American Society of Refrigerating Engineers, gives a list of quantities desired for the properties of steam, ammonia and other refrigerants, marking certain data that should be included in a brief table for every-day use.

I feel that the entropy properties should be included, and I strongly protest that gage pressures should not be given in the table for the simple reason that the tabular gage pressure would have to assume average barometric conditions, and in any use of the table the true barometric pressure would have to be added to the corresponding observed gage pressure, after which the standard barometric reading would be subtracted before the table could be used. This is more cumbersome than giving the absolute pressure in pounds per square inch in the table with change for corrections in barometric pressure.

The barometric reading should be added to the corrected gage reading and then the standard barometric pressure subtracted in order to get the gage reading to use in the table. For approximate use standard barometric pressure need only be subtracted to get approximate gage pressure. If gage pressures are used in the table, we will have the same condition that we had in expressing vacuum in inches of mercury in place of absolute pressure in inches of mercury. This necessitated in all contracts the statement referring to 30-in. barometer.

I would suggest the following symbols for the quantities for which symbols have not been given by Mr. Matthews:

φi, for absolute pressure in pounds per square inch.
r, for latent heat of vaporization.
q', for heat of the liquid.
i, for total heat.
φ, for internal latent heat.
ψ, for external heat of the vapor.
m, for weight of one cubic foot of liquid.
m'', for weight of one cubic foot of saturated vapor.
v', and v'' would refer to the volumes of 1 lb. of liquid and saturated vapor respectively.

For entropy I would suggest the symbols s' for the entropy of the liquid and $\frac{r}{T}$ for the entropy of vaporization. These symbols would agree with standard textbooks on Thermodynamics such as that of Goodenough. They would also check with European practice.

I note in Mr. Matthews' communication and also in the table on page 96 of the same issue of *Power* that heat is referred to —40 deg. F. which also corresponds to —40 deg. C. For the case of refrigerating fluids there is an advantage in using this new datum plane as the heat of the liquid and the entropy of the liquid below 32 deg. F. remain as positive quantities in place of being negative. On first examining this table, I thought it would be disadvantageous to have a different datum plane for the steam tables and the tables of refrigerants. However, I believe that the value obtained from having all quantities in the table positive will more than offset the disadvantages arising from the fact that different substances will have different datum planes for the construction of tables. Although my first thought was to condemn this change from previous practice, on further consideration I think the step a good one and I heartily approve of it.

Troy, N. Y. ARTHUR M. GREENE, JR.

Are Small Boiler Tubes Desirable?

It appears that Mr. Riggin (*Power*, Jan. 25) has overlooked some points in his investigation of boiler tubes. Marks gives in his table, dimensions for a standard return-tubular boiler of 2,000 sq.ft. heating surface, one hundred and ten 3⅓-in. tubes having 2,015.9 sq.ft. of heating surface, against eighty-eight 4-in. tubes having 1,843.1 sq.ft. of heating surface. It will be seen, therefore, that the heating surface will be considerably increased by the use of the smaller tubes, and since the cross-sectional area of the one hundred and ten 3½-in. tubes is less than that of the eighty-eight 4-in. tubes, I fail to see how they decrease the water-storage space, steam-storage space or disengagement area.

They do, however, decrease the cross-sectional area of the tubes slightly, resulting in greater gas velocity. The advantage of this can be seen from the following, which is quoted from Bulletin 18, Bureau of Mines.

> In the future the velocity at which gases pass over the heating plates will be the factor that will be used for increasing the capacity of boilers. There is no valid reason why stationary boilers cannot be worked at two or three times the rate at which they are worked at present. If the same weight of gas at the same initial temperature is passed through a 2-in. and a 4-in. tube both tubes having the same length, the 2-in. tube will absorb more heat than the 4-in. tube.

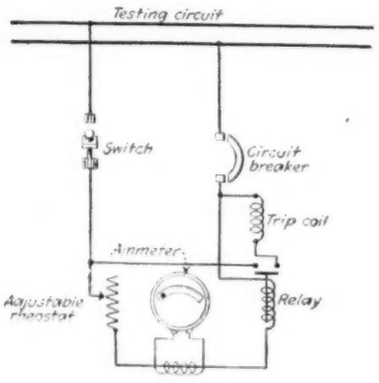
I will grant Mr. Riggin his point on the 3½-in. tubes being more trouble to clean that the 4-in. tubes, but I believe the advantages of having the proper size and number of tubes outweighs the disadvantage of having to clean them. T. G. ST. JOHN.

Mobile, Ala.

Testing Alternating-Current Relays

In the Jan. 18 issue of *Power*, Victor H. Todd presents an article on the testing of relays. There are two points that I believe should receive special emphasis with regard to this matter. The first is to see that the current is constant in the relay during its time of operation.

With the plunger-type relay, as the core rises the impedance of the coil is increased, which will lower the current value that is flowing through the coil, giving an incorrect reading of the time of operation if care is not taken to keep the current constant. Owing to the short period in which the relay operates, it is not possible to adjust the current as the core rises. This would be especially difficult, and quite noticeable if the relay was tested on circuit in which the voltage was transformed from 110 to 5 volts, as the article suggests, especially with this particular type of relay.



CONNECTIONS FOR TESTING RELAYS

To keep the current constant during the travel, it is satisfactory to test it connected to the secondary of a current transformer, which causes an increase of secondary voltage as the core rises, so as to maintain a constant current, or else have the relay coil connected in series with a resistance, so that the impedance of the relay coil is only 15 per cent to 25 per cent of the total resistance of the circuit. The increase of the impedance as the core rises, is then only a very small percentage of the total impedance of the testing circuit, and the current should remain quite constant during the operation of the relay. Before making any time observations, after the current value is adjusted, the plunger should be allowed to rise to its closed position to see if the current is still constant. In case it falls slightly, then more resistance is needed in series with the coil.

A second point of importance is to have the relay trip out a circuit-breaker rather than have it connected to an indicating circuit. This allows the relay to operate under conditions nearer to those met with in actual practice.

The current required for a trip coil is usually much larger than for a lamp, and the time of trip will be more accurately observed. The main advantage of this connection is that it allows the circuit to be opened as soon as the relay makes contact. Under tests where the current is several times normal load, the contacts might be injured or bent out of adjustment before the operator could open the circuit after the time has been observed. Such a scheme of connections would be made as indicated in the figure. The breaker not only opens up the line current, but also breaks the trip-coil current, so that there is no burning on the relay contacts only as the contacts are closed, making a circuit through the trip coil. HOWARD D. MATTHEWS.

Milwaukee, Wis.

Oil in Refrigerating Coils

In *Power*, March 1, 1921, E. C. Cunningham is looking for confirmation of his observations that oil does not keep floating on liquid ammonia.

Oil is lighter than water, but it is heavier than liquid ammonia. The following table gives the actual densities or weights of the liquids in question:

Liquid	Specific Gravity	Lb. per Cu.Ft.
Water	1.0	62.4
Ice-machine cylinder oil	0.9 to 0.94	56.1 to 58.6
Liquid ammonia		
At 86 deg. F. and 154.5 lb. gage pressure	0.596	37.15
At 5 deg. F. and 19.6 lb. gage pressure	0.659	41.08

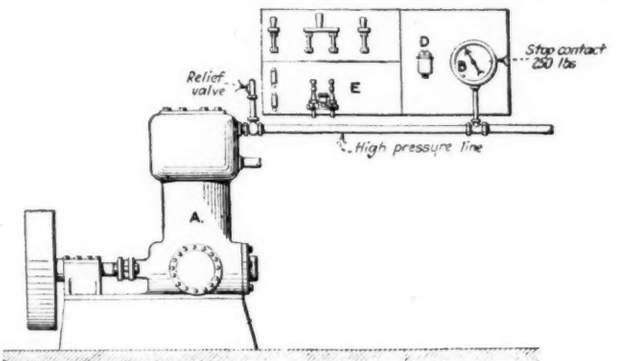
In a liquid receiver water, if any, would be at bottom, above this a layer of lubricating oil, and on top would lie the liquid ammonia. This is very fortunate, for it enables one to draw off easily these contaminating fluids at all low points, such as the liquid receiver, which latter should be utilized as the most effective oil-separating device in the plant.

New York City. CHARLES H. HERTER.

Safety Device for Ice Machine

We have a motor driven one-ton compression direct-expansion ice machine, used to furnish refrigeration for kitchen and water cooling. The machine is installed on the roof of an eight-story office building. Water is supplied from a tank on the roof, set about four feet higher than the machine. As city water pressure will not force water to the tank, a small motor-driven centrifugal pump is used and is connected to the city main.

Owing to fuses blowing out or repairmen shutting down the pump without notifying the attendant in the engine room, we were losing a charge of ammonia through the relief valve every two or three months. The head electrician finally had a contact gage put up



ARRANGEMENT OF CONTACT GAGE RELAY, SELF STARTER AND BLOWOUT SWITCH

which was connected to the high-pressure side of the machine and set at 250-lb. pressure.

Referring to the illustration, *A* is the ice machine, *B* is a contact gage. A contact point of solid silver on the gage is a connection to energize the relay *D*, as the contact points will not carry the heavy current. The relay *D* short-circuits the current through a shunt coil in the magnetic lockout self starter, which opens the main blowout switch *E*. Direct current at 125 volts is used. We have not lost a charge of ammonia through the valve since the installation of this gage. Now could not a device of this nature be used for machines operated by steam or other power, set to shut down at a predetermined pressure? RAYMOND TUTHILL.

New York City.

Why Producer Gas Power Is Not More Used

The question heading the article on producer gas power by M. W. von Bernewitz in the issue of Feb. 8 was only partly answered in that article. American engineers should learn more of this matter than is generally known. Motive power can be produced through the use of producer gas for one-third of the cost of its production by the use of steam.

The reasons why this cheaper power is not more used are numerous. They are, in part, as follows:

1. The limited and hazy knowledge generally held as to the best procedure to secure desired results. This applies to the heads of plants even to a greater degree than to engineers operating the plants.
2. A larger initial cost per horsepower for equipment is required than for the usual steam plant. An effective equipment is very far from being the inexpensive plant of the usual suction type.
3. The high cost of American labor and its lack of technical training.
4. Working capital has been used more profitably in other ways than in saving fuel.
5. Larger floor space is required for installations having all the requisite features.
6. Complexity in the process of making producer gas of suitable quality.
7. Basic difficulties in securing uniformity of quality in producer gas.
8. Steam power is more reliable. Its expansive force can be stored in smaller space, and the outflow of accumulated force is more readily controlled.

The eight reasons cited seem a big count against producer gas power, and there are still other reasons of lesser moment.

Nevertheless, when one realizes how wasteful of oil and of high-priced solid fuel is the power production of today, and in view of the high cost of fuels of all kinds, it seems probable that one of the most potent of all economic influences that could be exerted by the United States Government would be to show how to produce cheap producer gas power from lignite, bituminous waste, anthracite dust and cinders, Massachusetts' hard coal, and other carbonacious matters.

The most important matter to consider in this connection is that all operations in connection with the production of producer gas should be under the control of dependable steam power, and that steam power should be used as an auxiliary to initiate and equalize the motive force in the gas prime mover. The making of producer gas is a fine art and can be exercised only by trained human brains expertly manipulating a poke rod manually. Even with the best of mentality applied, uniformity of character in producer gas is difficult to attain. But there are in this art refinements that can be practically applied, that secure high character in this gas and almost unbelievable economy in its production. The simplified suction producer in which the prime mover incites the induced draft through the producer is a great cause of unsatisfactory results.

Every producer, to function well, must be structurally adapted to the fuel that is to be processed in the production of the gas. An intelligent preparatory preparation of the fuel that is to be used, is a *sine qua non* to the best results. To understand all these matters and to apply the knowledge successfully, involves a special education of the producer-gas engineer that I imagine few possess.

It seems obvious that this is a matter than can be successfully taken up only by a paid governmental agency, because many interests are opposed to seeing the world benefit in this connection. It is even doubtful whether it is going to benefit the engineering world to acquire the necessary technical knowledge in this matter, unless governmental or other influences are brought to bear in educating the public. The waste of fuel going on continually is appalling, especially when we consider that in a relatively short time the world will have a fuel famine. This is a subject that seriously relates to the future civilization of the race.

East Orange, N. J. J. M. W. KITCHEN.

Unbalanced Throttle Valves a Failure on Large Engine Stops

The correspondence entitled "Unbalanced Throttle Valves a Failure on Large Engine Stops," by George Van Vlack, page 75 of the Jan. 11 issue of *Power* is misleading to the young engineer who may be uninitiated in automatic overspeed engine stops, as it leads to the inference that all stops are of one ordinary type.

A small engine equipped with the style of stop he refers to is no safer than a large one, for while the area of the disc in the valve is less, making the total pressure it has to close against proportionately less, the weights that spin the throttle wheel will be lighter than in a large valve installation, so as to prevent the disc from being forced through its seat or closing so tight that it cannot be reopened without releasing the compression on the valve stem by loosening up nuts on the bonnet or breaking the yoke.

I have handled both the single-disc valve, closing against the steam pressure and the so-called balanced-valve engine stops and can cite instances where both have failed, the first being too slow in its action and the second sticking. Since the ordinary single-disc valve closing against the flow of steam, the windlass sprocket chain engine stop was brought out and experiments have been carried on continuously in developing reliable high-grade engine stops, which have resulted in designs that use either an independent quick-closing rotary-stem single-disc valve, closing with the steam flow, or a combined throttle and automatic quick-closing valve which closes with the flow of steam the same as the independent valve. While the two discs of the combined valve function entirely independently of each other, they are inclosed in one valve body. The simple quick-closing valve-operating mechanism is firmly held locked open until it is released by the speed limit, which releases the weight in case of an overspeed, and the disc is moved into the flow of steam, closing quickly but without slam, as a dashpot prevents this.

My intercourse with engineers has taught me that very few consider automatic overspeed engine stops until they have had a near runaway or a flywheel explosion, and that they consider it a frill, although they would not think of running a boiler without a safety valve and other safety devices. Engine stops are worthy of the engineer's consideration, for although he may be making himself believe his engines will not run away, this does not prevent metals crystallizing and breaking, causing a disastrous flywheel explosion.

Philadelphia, Pa. S. C. H. STEVANS.

Fire-Engine Hose Ignites When in Use

In Boston, recently a new 50-ft. length of the usual 2½-in. hose, consisting of a simple rubber lining inside a heavy cotton jacket, outside of which was drawn a similar cotton jacket, was being used in a test made on some new pumping engines. The stream was throttled down about 45 per cent, discharging about 250 gal. per minute, and notwithstanding the fact that this quantity of cold water was passing through it, the hose took fire between the cotton jackets. A spot 2 in. long by 1¼ in. wide was burned through each. Careful examination revealed the fact that on each side of the burned hole the inner castings or jackets were severely chafed. This chafing, coming from the vibration produced in the hose by the pump, was sufficient to produce great heat and finally active combustion. I found also a similar state of things in another sample of hose used in a later test. The chemical composition of the rubber is believed to have had nothing to do with the case. I am of the opinion that the occurrence was due to excessive friction between the cotton casings produced by the vibration of the hose in service.

It is interesting to note that these results have been confirmed by J. S. Caldwell, chief engineer of the New England Insurance Exchange, with three different types of engines and three different makes of high-grade standard hose. The experiments were made in Portland, New Bedford and Boston, and in some cases the cotton was charred in about fifteen minutes.

Cambridge, Mass. A. H. GILL.

Injector Replaced Centrifugal Pump As Boiler Feed

After the new power plant began taking the greater part of the load, the old plant was put on part time operation. Under the existing conditions it is only necessary to keep a few boilers hot for the greater part of the day, for the maximum load is not more than 10,000 kw. and this does not come until late afternoon and evening. With these conditions prevailing there was a loss in the use of our feed water system. It was evident that we needed a method by which the water could be fed during this shutdown period with less loss.

We have an open heater from which the water feeds by gravity to steam turbine-driven centrifugal pumps. To run this turbine, 150 lb. pressure had to be held, and as this pump was the only demand there was very little water needed by the boiler, therefore little went through the heater and practically the entire exhaust from the turbine was a loss. The boiler-room foreman suggested that an injector be used to feed the water. This injector was placed in the line from the water softener in such a way as to shunt the heater. We now carry 175 lb. pressure and generate just enough steam to operate the injector.

Under the old system we had an appreciable loss in live steam; now "our loss is that of hot water from the injector. Even a part of this water is reclaimed by feeding it back into a tank, where it mixes with the water from the softener, just before it goes to the injector. As much as possible is reclaimed but not enough to heat the water above 90 or 95 deg. As modern central-station losses are made up largely of numerous small losses, we feel that we have accomplished something worth while in a rather unique way.

Toledo, Ohio. THOMAS J. NOLAN.

Treatment of Direct-Current Motors

In the Jan. 4 issue of *Power*, Mr. Wilson brought up some interesting points in connection with my article in the issue of Oct. 12, 1920. In the last few years my time has been devoted largely to the rehabilitation of run-down plants. Much of the trouble encountered has originated in the methods used in repairing the motors. In many cases coils of cotton-covered wire were placed in the slots without treatment, the only paint being the coat over the tape. This coat usually does little good except for looks.

In preparing the article, I wished to bring out the benefits of the dipping and baking process and to destroy the impression that it is a complicated and highly technical procedure.

The varnish used was selected by a process of elimination and has given excellent results. It is one of the commercial insulating varnishes on the market and I would hesitate to say the only one suitable, as I have tried a number with satisfactory results. The asphalt and paraffin compounds with which I have experimented have been discarded, as they were all somewhat soluble in the lubricating oils used. We have never noticed any action on the varnish used if properly applied. If the armatures are heated and thoroughly immersed in the varnish and allowed to soak and then baked at a moderate temperature, there are no openings for the oil to enter the coil and any action must be on the outside. The checking due to the drying out of the varnish in time does not extend to any great depth in this case. The interior of the coil must be filled thoroughly and this takes a complete submersion and considerable time.

One point I neglected to mention was that after the armature was ready for assembly it was given a coat of oilproof finishing varnish with an air spray. This was done more for the nice appearance of the black glossy coat than to keep out the oil. During the war this coat was frequently omitted owing to the difficulty of obtaining the alcohol varnishes. No bad effects were noticed from this omission, however.

The corrosion mentioned by Mr. Wilson may have been due to another cause. I have noted similar corrosion and have traced it to the electrolytic action of the leakage currents through the moisture in the coils in some cases. In a mine the moisture, whether due to condensation or to drip, will contain acid or soluble salts and probably both. These will be concentrated by evaporation. The varnished cloth will be impervious to the moisture that will collect at that point. Any corrosive action of the acid or salt in the water will thus naturally result next to this cloth. In our experience we have never noticed any corrosion in the impregnated coils.

Several hundred motors that have received this treatment have come under my observation. These motors have operated under almost every conceivable condition in which a motor should not be expected to give satisfactory service, from extremes of moisture to extremes of heat, and in no case was trouble noticed that could be traced to the varnish.

I agree with Mr. Wilson that a more general discussion of the question will be of benefit. If we are to raise the operating temperatures with the 50-deg. motor, more attention must be paid to this point as cotton insulation will stand more heat without charring after it is treated and the safe margin will be rather small in many cases.

El Paso, Tex. T. H. ARNOLD.

INQUIRIES OF GENERAL INTEREST

Disengagement Surface.—What effect has the extent of steam disengagement area on the operation of a boiler? R. L. N.

If too much steam escapes from an area the surface of the water will be kept highly agitated and cause priming, and may cause the water gage to falsely indicate the water level in the boiler.

Use of Copper Steam Pipes—Why is little use made of copper for steam-engine supply pipes? A. S.

Copper pipe rapidly deteriorates under high pressure and repeated stresses such as are introduced by expansion and contraction from changes of temperature, and its strength is considerably reduced by increase of temperature. Aside from greater cost copper pipe is not generally regarded as safe for use with pressures and temperatures of steam commonly employed in modern steam-engine practice.

Electrical Losses in Central Stations—In a central station, how are the electrical losses distributed in the generators, cables and switching? A. R.

In a modern plant of moderate size, equipped with generating units of 5,000 to 10,000 kw. capacity, it may be said that the generator losses at full load will be between 3.25 and 2.75 per cent. The losses in cables depend mainly on the length, but will probably never exceed 0.35 to 0.40 per cent at full load, including all contacts. The losses in the bus and switching equipment should not exceed 0.5 per cent.

Change of Water Level in Water-Column Fixtures.—Why does the water stand higher in the glass gage of a boiler for some time after the water-column connections have been blown off? J. E.

With the same steam pressure in the upper part of the water column and gage glass, a fresh supply of water from the boiler is carried by its momentum to a higher level, and on account of frictional resistance of the pipes and fittings a short interval of time may be required for the water level to fall in the water column while equilibrium of pressure is becoming established in the connection with the water in the boiler. The water thus admitted to the water column and connections is of higher temperature, and consequently is of less density than the water that was blown off; and when the freshly admitted water is superimposed by the same or less steam pressure in the upper part of the water column fixtures the new water will be supported to a greater height of column for the same head of water and superimposed pressure of steam in the boiler.

Lubricator Connections on Opposite Sides of Throttle—Why does an engine lubricator that has two separate connections with the steam pipe, operate better when both connections are made above the engine throttle valve? E. D.

When both connections are made above the throttle valve, there is practically the same pressure in each connection and the effective pressure for discharge of oil from the lubricator is equal to the constant pressure due to the head of water in the condenser. On account of the sudden drafts of steam by the engine there is continual fluctuation of pressure on the steam-chest side of the throttle valve, but the variations of pressure are less above the throttle valve, especially when the throttle is partly closed. Hence, with one lubricator connection made above and the other below the throttle, although the pressure due to the head of condensing water might be constant, there would be continual variation in the difference of pressure in the connections and consequently variation of the effective discharge pressure, and the discharge of oil for a given adjustment of the needle valve would be irregular.

Performance Guarantees of Turbo-Generator—Referring to the article entitled "Performance-Guarantees for a French Turbo-Generator," page 314, Feb. 22 issue of *Power*, are we to understand that by raising the power factor from 80 per cent to unity, the steam consumption of the turbine would be reduced? C. K. B.

It is customary in Europe to apply the term "load" on a generating unit to indicate the "true" load, measured in kilowatts, and not the "apparent" load, measured in kilovolt-amperes. If the true load on the unit in question is kept constant at 4,000 kw. and the power factor raised from 80 to 100 per cent, the kilovolt-amperes decrease from 5,000 to 4,000, by the reduction of the armature current. The copper loss in the armature is therefore decreased, and the steam input to the turbine which must supply this loss is lowered. If the steam consumption is meant to include that of the auxiliaries, which is the case in the article referred to, the total steam consumption will be further reduced, since raising the power factor of an alternating-current generator decreases the demagnetizing effect of the armature current, therefore less excitation is necessary, and the steam or electric power consumption of the exciter unit will be reduced. The foregoing statement refers to a lagging power factor only, which is the condition to be found in the large majority of power houses under normal loads.

Equivalent Evaporation With Percentage of Moisture.—When feed water at the temperature of 162 deg. F. is converted into steam at the pressure of 150 lb. gage, containing 7 per cent moisture, what is the equivalent evaporation from and at 212 deg. F.? R. L. G.

A pound of dry saturated steam at the pressure of 150 lb. gage, or 165 lb. per sq.in. absolute, contains 1,195 B.t.u., of which 338.2 B.t.u. is the heat of the liquid, or the amount of heat required to raise a pound of water from 32 deg. F. to the temperature of evaporation at the stated pressure, and 856.8 B.t.u. is the latent heat of evaporation at that pressure. If the steam carries 7 per cent moisture, then only 93 per cent of each pound of the mixture has received the latent heat of evaporation and the total heat contained per pound would be $338.2 + (856.8 \times 0.93) = 1{,}135$ B.t.u. above 32 deg. F. With the temperature of the feed water 162 deg. F., or $162 - 32 = 130$ deg. above 32 F., each pound must have received $1{,}135 - 130 = 1{,}005$ B.t.u., and as the latent heat of evaporation at 212 deg. F. is 970.4 B.t.u. per pound, the heat received per pound of the feed water is equivalent to the evaporation of $1{,}005 \div 970.4 = 1.036$ lb. of water evaporated from and at 212 deg. F.

Design of the Steam-Power Station for Hydraulic Relay*

By E. B. POWELL

SUPPLEMENTAL power in some form is an essential to the further commercial development of our Eastern water powers. The nature and extent of this supplemental, or relay, power will be governed in a large measure by the character of the stream and the amount, character and location of the load and importance of continuity in power supply.

In many instances the required relay, at least sufficient for the initial development, may advantageously be provided in the stream itself by adding reservoirs, or merely pondage, to give some artificial control of the flow. In other instances, the electrical interconnection of water-power systems, by pooling the water resources of dissimilar streams, may also afford sufficient initial relay in hydraulic power. In general, however, the fullest commercial utilization of water power can be had only by the aid of independent relay, which in the greater part of the country today is most satisfactorily and economically provided in the steam-power station.

The functions of the relay, while they may vary widely, are of two general types, flow or head deficiency makeup and emergency reserve, the second being supplemental to the first. For either type of service the capacity required in any particular case will depend on the amount and characteristics, initial and prospective, both of hydraulic development and of load. The design, while broadly determined by the usual factors which control in the case of the independent central station, is in general, on account of the commonly low load factor, less dependent on considerations of operating economy. On the other hand, character of load and dependability of delivered hydraulic power are factors of prime importance, and for proper realization of the economic possibilities of the development as a whole, the design should also be governed in many important features by the characteristics of the hydraulic development and the relation of that development to the load.

*Abstract of paper presented at a joint meeting of the Boston sections of the American Society of Mechanical Engineers and American Institute of Electrical Engineers and the Boston Society of Civil Engineers, Feb. 7, 1921.

Considering first the station intended solely to make up the power deficiencies of the hydraulic development, its functions may include any one or more of the following: (a) Seasonal operation to make up deficiencies in hydraulic power from low water or flood; (b) absorption of load growth between stages of hydraulic development; (c) operation as the main source of power. As reflected in the functions of the relay station and as affecting its design, hydraulic developments may be grouped as of four general classes:

I. Minimum Flow Development. — Developed hydraulic capacity equal to or exceeding maximum system load. Resultant minimum available flow only slightly, and for a brief period in the year, below corresponding load requirements. Reserve provided in hydraulic station.

II. Medium Flow Development. — Developed hydraulic capacity equal to or exceeding maximum system load. Resultant minimum available flow below load requirements for a considerable period, 40 per cent or more, of the year. Reserve provided in hydraulic station.

III. Continual Relay Development.—Available hydraulic capacity slightly below system load requirements throughout the greater part of the year.

IV. Supplemental Development.—Hydraulic development merely an adjunct to the steam-power station, which carries the bulk of the load.

The type of reserve referred to in Classes I and II is for relay against failure of equipment within the hydraulic station itself. Under the conditions outlined, this reserve may often advantageously be installed as part of the hydraulic station rather than in the steam station. As is well known, from 50 to 75 per cent of the cost of the average hydraulic development is fixed and independent of the capacity installed, so that sufficient capacity for this type of reserve may frequently be included at comparatively low unit cost.

It will usually be found that the conditions represented by Classes I, II and III are merely stages in approach to those of Class IV. This is especially true in the East. However, the change in relative status of the hydraulic- and steam-power stations may be very slow, particularly so

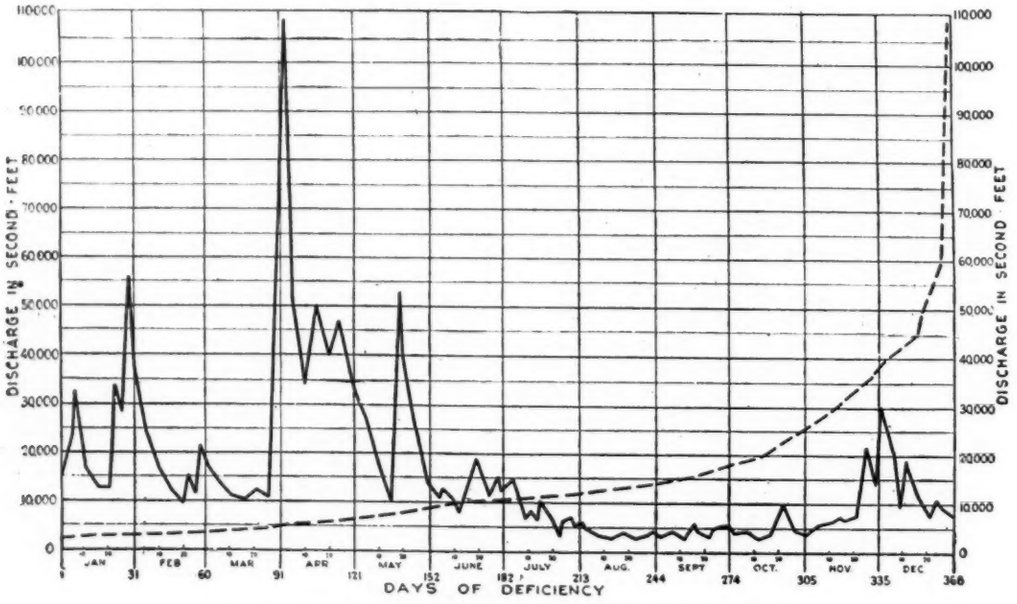


FIG. 1. DAILY HYDROGRAPH AND DEFICIENCY CURVE, 1916, HUDSON RIVER AT TROY DAM, N. Y.

where a series of hydraulic developments may be brought in successively, as warranted by load conditions; in which case to pass beyond the conditions of Class II may require a matter of decades. For these reasons the entire project should be studied broadly in the beginning, both as to the ultimate physical possibilities and limitations of the hydraulic development, or developments, and as to the character and probable growth of the market for power.

The seasonal flow of the Hudson River in New York is so variable that the hydrographs of two successive years, 1915 and 1916, with their corresponding deficiency curves may be used in illustrating developments of all four of the classes just referred to. In Fig. 1 it will be seen that if this hydrograph is assumed to represent the year of minimum flow for a particular stream and if a flow of about 3,000 sec.-ft. would supply the maximum power requirement, a development providing proper equipment reserve at this flow would approximate the conditions of Class I. If growth of load raises the daily power demand above the capacity of the available minimum stream flow, and this growth of load is accompanied by a corresponding increase of generating capacity of the hydraulic station to utilize, may be judged from reference to Fig. 3, which shows a typical manufacturing town load with the "per cent load" curve superimposed for convenience of interpretation. If the minimum flow is assumed equivalent to 50 per cent of the day's energy requirement, with full 24-hour pondage provided, the hydraulic station could take off the upper 70 per cent of the demand, permitting the relay station to carry the base load at a daily load factor approximating 90 per cent with a demand only 30 per cent of the total. On the other hand, in the absence of pondage, the relay station must be designed to carry about 75 per cent of the total demand, and on this basis its daily load factor would be reduced to about 40 per cent. It is apparent that, in the absence of pondage, higher capacity will in general be required in the relay station and the relay-station load factors, both daily and annual, will tend to lower values than where full pondage is provided.

Referring again to Fig. 1 it will be seen from the deficiency curve that if the maximum load demand is within the capacity of the 3,000 sec.-ft. flow which is the developed capacity considered for Class I, the relay station except for conditions of equipment failure should not be called

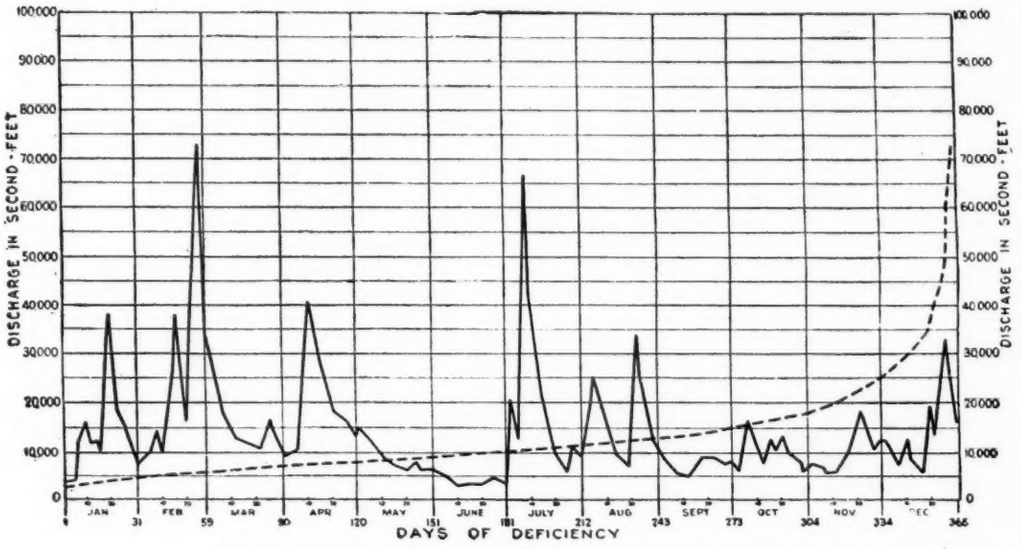


FIG. 2. DAILY HYDROGRAPH AND DEFICIENCY CURVE, 1915, HUDSON RIVER AT TROY DAM, N. Y.

say, 8,000 sec.-ft. to 10,000 sec.-ft., with proper reserve, the conditions become those of Class II. Turning to Fig. 2, development of the hydraulic plant to utilize a flow of, say, 10,000 sec.-ft. to 12,000 sec.-ft. with daily load demands somewhat in excess of the mean available flow would give the conditions of relay service under Class III. Continued growth of load with a single hydraulic development as applied to either type of stream flow will ultimately bring about the conditions of Class IV.

Of course, in the case of many streams it would be feasible to provide sufficient reservoir storage to smooth out the stream flow to a very material extent, thus raising the minimum or primary capacity of the potential development beyond the maximum load demands considered above under Classes I and II at least, and possibly beyond that considered under Class III. For purposes of the present discussion, however, reservoir storage, as distinct from pondage in the usual sense, will not be further considered, as the effect of adding reservoir capacity in the development will introduce no new conditions of relay service distinct from those applying under the four groups discussed, but may merely shift the development on the scale of the present classification, or possibly remove the occasion for independent relay, from a capacity viewpoint. Pondage, on the other hand, does not affect the seasonal variation of the stream; it provides regulation of the daily flow.

The effect of pondage on the relay-station requirements upon for operation in excess of 5 per cent of the year. It is not uncommon for relay stations under such conditions to stand idle an entire year. Obviously, for service of this character the actual operating economy of the relay station is of relatively small moment. The important considerations are low fixed costs and dependability.

For the extremely low load-factor conditions of Class I, type of equipment, dimensions and arrangement must all be studied with a view to attaining the desired output with minimum investment, compatible with simplicity of station and low cost of attendance. The type of combustion equipment and the arrangement of furnace must, of course, be governed by the character of fuel available. Oil is the ideal fuel for any type of steam relay station, but is not widely available commercially in sufficiently dependable supply. At the present stage of development pulverized fuel involves a greater degree of complication than is usually warranted in the station designed for the extremely low load-factor conditions of this case. Coal in its ordinary form will in general be the most satisfactory fuel. The stoking equipment should be of the forced-draft type for high capacity, either underfeed or chain grate, depending upon the class of coal.

The selection of the type and size of boiler, the decision as to total rated boiler capacity to be installed and the proportioning of combustion equipment to boiler-heating surface must take into account not merely the cost of that

equipment only, but also the costs of building and all related equipment such as fuel- and ash-handling facilities and mechanical draft. The cost curve of Fig. 4 shows that for the particular case considered, when all related factors are taken into account, boiler-heating surface may be installed to the comparatively high ratio to grate area of 50:1 without appreciable increase of total boiler-plant cost.

In Fig. 5 the curves show, for a particular set of conditions, at *A*, the relative construction costs for condensing

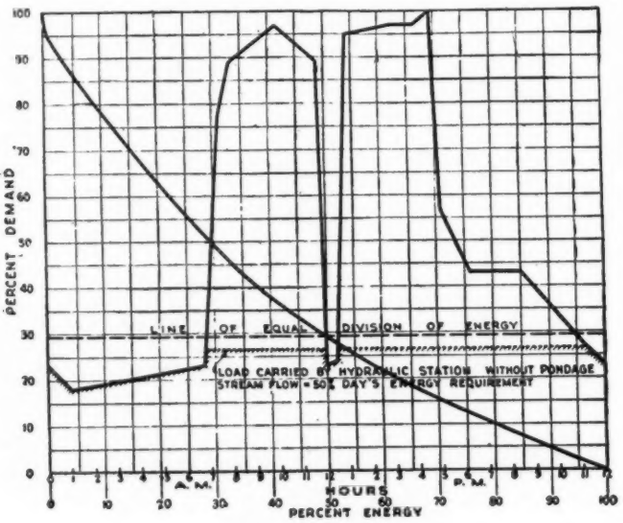


FIG. 3. TYPICAL MANUFACTURING TOWN LOAD, 24-HOUR LOAD FACTOR 53 PER CENT

equipment to attain different degrees of vacuum, the cost of the 29.0-in. design being taken as 100 per cent; at *B*, drawn to the same scale, the increase in boiler-plant cost resulting from the increased total steam demand which is had from different degrees of vacuum less than 29.0 in., and at *C*, which is a summation of *A* and *B*, still expressed in terms of 29.0 in. condensing-plant cost, the resultant effect upon total station cost, of designing the plant for different degrees of vacuum.

These two charts, Figs. 4 and 5, are correct, as to detail, for the particular conditions only for which they were estimated, but they clearly illustrate the interdependence of equipment costs and the importance of taking all related factors into account in deciding upon the type and size of apparatus.

As the system load grows, if the period of relay station operation is permanently lengthened, taking the development into the conditions of Class II for example, the higher load factor on which it may be possible to operate any new equipment may justify greater consideration of actual operating economy.

Further growth of load and extension of the operating period for the relay station into the conditions of Class III will justify in new equipment still further consideration of operating economy, until, as the conditions of Class IV are reached, practically the same factors govern as in the usual independent type of central station.

Fig. 6 shows the power costs from two types of station operating on the same conditions of load. Station *A* is designed initially for relay service under Class I conditions. Improvement in load factor is accompanied by the installation of such additional equipment and of such economic characteristics as may be warranted. Station *B* is designed for continuous operation at 50 per cent annual load factor. Its first cost is nearly 50 per cent higher than that of the initial step of station *A*, and while more economical at the load factor for which it is designed, on the lower range of load factors the higher efficiency of its equipment is insufficient to balance the higher fixed charge. Accordingly, where there is doubt as to the actual load factor at which the relay station may be called upon to operate, it will in general be advisable to design for the minimum probable load factor rather than risk unnecessary expenditure in providing for load conditions that may require years to attain.

Turning now to the station which must also function as an emergency, or breakdown reserve, the emergency service required of such a station may vary from floating capacity for instant availability to merely providing against interruptions of several hours or days.

Miscellaneous power service and lighting should, in general, be completely relayed against more than momentary interruption; for some classes of power—frequently that applied to electrolytic processes, for example—longer interruption of service is not of so serious moment, not sufficiently serious to warrant the expense of full relay; on the other hand, an extensive direct-current network, such as that in large metropolitan cities, must be absolutely safeguarded against interruption, however brief.

When the steam relay station is to serve as an instantaneously available reserve the necessary excess capacity in generating units must be maintained on the line and actually under steam at all times. Station design to provide most economically for such service must afford for minimum investment a maximum of flexibility in capacity, with minimum stand-by charges. Characteristics in equipment peculiarly favoring these requirements are:

1. Combination electric-steam drive on the larger auxiliaries, such as circulating pumps and mechanical draft fans, for the units operated as floating stand-by.
2. Turbo-generating units with direct-driven exciter, and with overspeed controlled steam bypass for turbine-blade cooling independent of normal governing valves.
3. High ratio of turbo-generator capacity in comparison with point of lowest water rate.
4. Wide flexibility with quick response in control of boiler output and rate of combustion.
5. High ratio in capacity of combustion equipment versus area of boiler-heating surface.

The first two of the characteristics mentioned are of advantage chiefly where the stream station is used exclu-

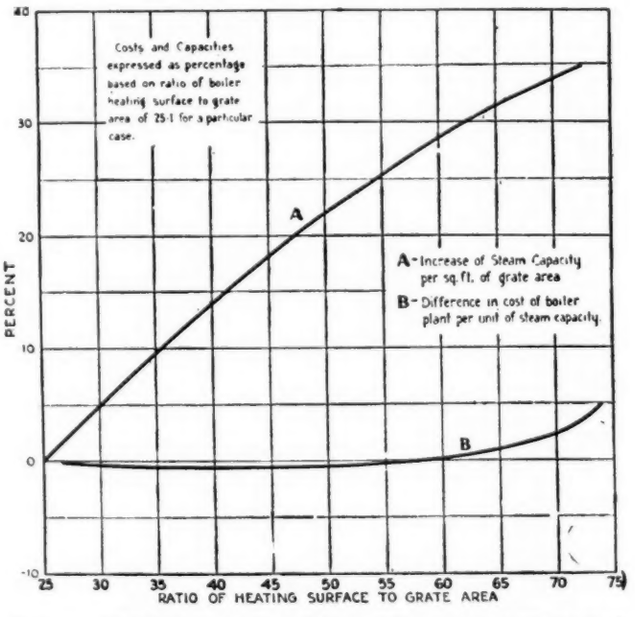

Costs and Capacities expressed as percentage based on ratio of boiler heating surface to grate area of 25:1 for a particular case.
A
B
A- Increase of Steam Capacity per sq. ft. of grate area
B- Difference in cost of boiler plant per unit of steam capacity
PERCENT
RATIO OF HEATING SURFACE TO GRATE AREA

FIG. 4. BOILER-PLANT CONSTRUCTION COST AND CAPACITY AS AFFECTED BY RATIO OF BOILER HEATING SURFACE TO GRATE AREA

sively for relay; they tend to reduce the stand-by fuel costs by permitting the reserve units to float on the hydraulic system with but negligible consumption of steam. The importance of the third characterisitc is particularly evidenced where the steam station normally operates as a generating station in parallel with the hydraulic station;

the excess capacity may thus be carried in the units under load, without serious loss of operating economy. The two characteristics last mentioned, those referring to the design of boiler plant, are essentials to maximum service from the stand-by station under any condition.

Where commercially available, fuel oil with mechanical atomization is particularly advantageous on this class of service; its use permits the fulfillment of these boiler-plant requirements to an almost ideal degree. With proper design the response to control is practically instantaneous; capacity attainable is the highest of any commercial fuel. Oil fuel has the added advantage, particularly important in stand-by service, of minimum banking loss.

Pulverized coal, bituminous or sub-bituminous, for the larger plants, is second only to oil in flexibility of control and low banking loss. In general the underfeed type of mechanical stoker, given proper ratio of grate area to heating surface, will also fully meet the requirements in both flexibility and capacity. The banking losses are, however, necessarily higher than for either oil or pulverized coal.

Emergency relay service on loads for which absolute continuity is of less vital importance will normally involve actual readiness to serve only during periods of anticipated power deficiency such as between seasons when stream flow is precariously near the actual load requirements and any slight diminution of flow will necessitate calling upon the relay station, or when there is possibility of sudden ice accumulation, or floods threaten curtailment of head.

For relay service of this character it will usually be sufficient to maintain a few boilers under fire and the larger of the essential auxiliaries turning over. The general

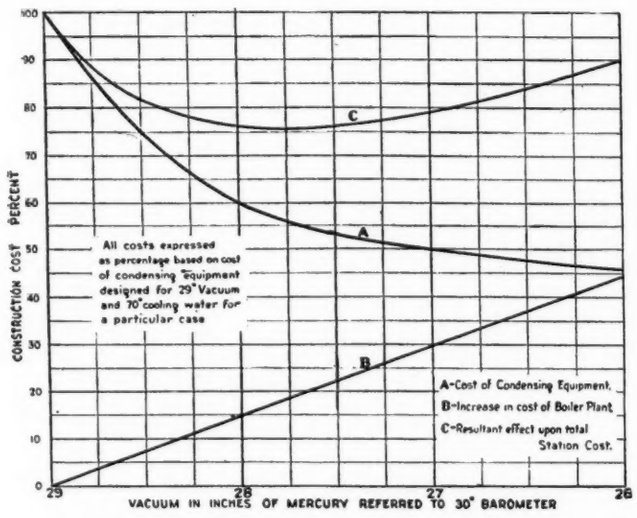

CONSTRUCTION COST PERCENT
All costs expressed as percentage based on cost of condensing equipment designed for 29" Vacuum and 70° cooling water for a particular case
C
A
B
A-Cost of Condensing Equipment.
B-Increase in cost of Boiler Plant.
C-Resultant effect upon total Station Cost.
VACUUM IN INCHES OF MERCURY REFERRED TO 30" BAROMETER

FIG. 5. RELAY STATION CONSTRUCTION COSTS AS AFFECTED BY CAPACITY OF CONDENSING EQUIPMENT

characteristics of equipment outlined for conditions requiring instantaneous availability of the reserve apparatus will be advantageous in this case also. The combination electric-steam drive for auxiliaries may be omitted in the interest of first cost as the relay is not necessarily intended to meet full failure of hydraulic power, but the provision of electric drives for one complete set of essential auxiliaries, as recommended for the normal deficiency make-up type of relay station to permit prompt starting of such equipment without waiting for steam, will usually be found particularly advantageous under the service conditions now considered. It may also under some conditions be advantageous to make use of electrical heaters in maintaining hot-water circulation in certain of the boilers, instead of actually holding them under fire. Oil is again the ideal fuel, but it is questionable if in the average case pulverized fuel will possess any advantage over the forced-draft underfeed stoker. New developments may, of course, readily change the relative status of these two methods of burning coal. In general the features of design which are specially advantageous for this type of relay are common to the instantaneous type of relay and are readily embodied in the station designed for the simpler type of make-up service.

Considering again the general characteristics and requirements of the steam relay station, the feature which should be regarded as secondary only to low construction

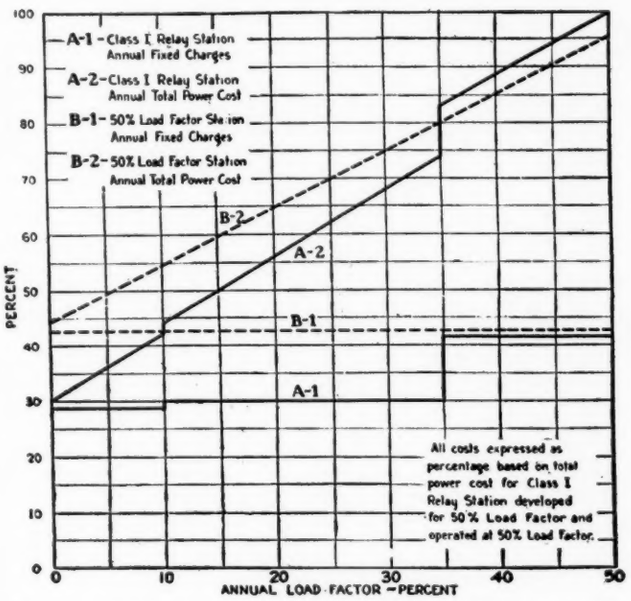

A-1 - Class I Relay Station Annual Fixed Charges
A-2 - Class I Relay Station Annual Total Power Cost
B-1 - 50% Load Factor Station Annual Fixed Charges
B-2 - 50% Load Factor Station Annual Total Power Cost
B-2
A-2
B-1
A-1
PERCENT
All costs expressed as percentage based on total power cost for Class I Relay Station developed for 50% Load Factor and operated at 50% Load Factor.
ANNUAL LOAD FACTOR — PERCENT

FIG. 6. ANNUAL POWER COSTS OF STEAM RELAY STATION AS AFFECTED BY LOAD FACTOR FOR WHICH PLANT IS DESIGNED

cost and adequate dependability is that of low attendance requirements, and not merely for the non-operating period but for actual operation as well. With this object the design should tend to large units and, as far as compatible with thorough simplicity, to automatic control. Where feasible, combining the functions of the distributing station with those of the hydraulic relay assists materially in holding down both construction costs and attendance for the relay station. It should be borne in mind, however, that maximum returns on the investment in any type of steam-power station can only be had through skilled and well-trained operators. Such men cannot be picked up on a moment's notice. It is true that it is often possible during periods of plentiful water supply to distribute men from the steam stations through other departments, but the number of men that may actually be employed in this way is limited. Where men are held over long periods without really effective employment there is invariably loss of efficiency and of morale.

The Czechoslovakian government has approved of the plan for the utilization of the large power resources of the River Thaya, which, when completed, will be one of the largest hydro-electric power plants in Europe. At first only a part of the project will be carried out, providing approximately 80,000,000 kw.-hr. a year. This part of the plant comprises two dams and several weirs a little above the town of Znaim. The plans are completed in every detail and the Czechoslovakian government is now engaged in completing the financial part of the project. The utilization of the Thaya water-power has been under contemplation for many years and long before the Czechoslovakian State was established. It speaks well for the enterprise of the young Czechoslovakian republic that it will accomplish in the first years of its existence what the old empire left undone for decades.

Developments in Conversion Apparatus for Edison Systems*

Conversion apparatus for Edison systems has taken three different forms, depending on the required voltage range and service conditions, the motor-generator set, the synchronous converter and the dynarotor. Different voltage ranges are further obtained with the synchronous converter by means of transformer-tap changing switches, of induction regulators, of regulating or split-pole construction, or by field control. Synchronous converters have been used mostly on 25-cycle systems and motor-generator sets, both induction and synchronous, on 60 cycles. The synchronous booster has superseded the induction regulator because of lower cost, greater reliability and simpler wiring.

The field-controlled converter was developed to meet the need of a limited-voltage-range machine. At unity power factor it operates as a simple converter and its commutation requirements are equally simple. When the power factor of the input is leading, however, the armature reaction demagnetizes the commutating pole, and vice versa when the power factor is lagging, and a second winding on the commutating pole, energized and controlled from the main field rheostat, is required to neutralize this effect.

The shunt-wound converter can be operated with equal stability over a greater range of reactive current and with more reactance in the alternating-current circuit than the compound-wound machine. The best efficiency is obtained with maximum lagging reactive current at no load and minimum voltage.

In large substations where the total voltage range of the substation is split up between three direct-current buses an important consideration, when several machines are operating in parallel on each bus, is the voltage range of the individual buses. The wide-range machines are connected first and the narrow-range machines are connected last and disconnected first. Suitable switches for changing the transformer connections with the transformer unexcited make a narrow-range machine available for any bus.

Field-Controlled and Synchronous Booster Converters Compared

The following is a comparison of the field-controlled and the synchronous booster converter, as deduced from tests on a 4,200-kw. field-controlled and a 3,500-kw. synchronous booster converter and transformer: (1) The efficiency of the field-controlled machine is the higher, although it varies considerably over the voltage range, and a transformer connection should be chosen to give maximum efficiency at the operating voltage; (2) successful commutation is obtained in the field-controlled machine over the voltage and load range without relays or special rheostats; (3) the field-controlled machine has better ventilation and accessibility of parts; (4) for voltage ranges up to 10 per cent the field-controlled is the cheaper machine; (5) it occupies less floor space; (6) the synchronous booster converter may be operated at unity power factor over the entire range of voltage and load, while the power factor of the field-controlled machine cannot be adjusted independently of the voltage; (7) the synchronous booster converter may be designed for a large voltage range, while the field-controlled converter is limited to a maximum range of 10 per cent; (8) when starting from the direct-current side, it is not possible to vary the alternating-current voltage of the latter while synchronizing; (9) the field-controlled converter is simpler than the synchronous booster converter.

The dynarotor is a synchronous converter in which the alternating and direct currents flow in separate windings in the same armature slots. The advantage over the synchronous converter is that the alternating current may be under high tension, thus eliminating the transformer and heavy low-tension connections. The over-all efficiency of such a unit is slightly higher than that of the synchronous booster converter with its transformer and connections, higher than the motor-generator set, but lower than the field-controlled converter and transformer.

There have been no recent important developments in direct-current, induction-motor or secondary-tap starting of converters. High-tension starting, however, is coming into more general use, as it simplifies the low-voltage connections and eliminates heavy current switches. Three methods are used—series-multiple, star-delta and extended primary.

Motor Generator Sets

Some Edison motor-generator sets are compound wound, some differential wound so as to operate successfully in parallel with batteries; but shunt generators are now being designed to replace the latter. Some units are equipped with a differential field winding which is normally short-circuited, and becomes energized only in case of a short-circuit on the generator, to cut down the field and decrease the short-circuit current.

The unit is usually so connected that full voltage may be impressed in starting, if necessary to rapidly restore service. To protect the motor under these conditions reactors are connected in the alternating-current line; the field circuit of the motor is controlled by a device that is responsive to slip; the stator winding is protected against overheating by a thermal relay, the damping winding by a definite time-limit relay, which allows the synchronous motor to run as an induction motor for a certain length of time only.

The motor-generator set as developed for Edison service will give such continuity of service as to supplement the battery and consequently the necessary battery capacity may be reduced.

Automatic Substations

The advantages of automatic converter substations for railway work have been recognized; also semi-automatic remote-control for power and lighting; but Edison systems have not as yet tried automatic operation of substations. No hard and fast rule can be made, however, for every system has its specific problems. Yet there is probably a place on every Edison system for an automatic substation.

Discussion by Members

In discussing the paper B. G. Lamme reviewed the development of the rotary converter and pointed out that field control was the first method known for voltage control of synchronous converters. Since then various schemes for voltage control have been developed and used, such as split-pole converters, synchronous-booster machines, induction regulators; but today the trend is back to the simple field-control type.

F. D. Newbury questioned the impression given in the paper that in general the efficiency of the booster type converter is lower than that of the simple field-control type, since recent tests which he has made showed the opposite to be the case. Mr. Newbury was of the opinion that both the field-control type and booster type machines have their field of application.

Raymond Bailey did not consider the series-multiple and extended primary windings methods of starting good practice, but recommended the star-delta method. He told of one arrangement where the switches were so arranged that when the starting switch was pulled the running switch was closed automatically, which allowed a very short period between the breaking of the starting circuit and the application of the running voltage. The speaker also favored switching on the high-voltage side of the transformer.

Philip Torchio took exception to the statement that a motor generator with characteristics as described in the paper will give continuity of service on any Edison system equal to that of the generating system supplying the power, and therefore the motor generator supplements the storage-battery capacity required to give a system protection against momentary interruption of the alternating-current supply. Mr. Torchio said that the standard set by the New York Edison Co. was never to allow the service to its customers to be interrupted. To obtain this end it was the practice to install storage-battery capacity in each substation sufficient to carry the maximum load for from eight to ten minutes, and also to supply each substation

*Abstract of paper by T. F. Barton and T. T. Hamilton, both of the General Electric Co., presented at a meeting of the A.I.E.E. on March 11, 1921.

with alternating-current power from two separate power houses over independent routes. He said he could recall five complete interruptions to the service in some of his company's plants, but in no case was there any disturbance to the customer's service that would indicate any trouble on the system. In most cases voltage was on the bus again in less than one minute after the interruption, so that the system operator could begin getting converting apparatus back in service again. In no case have the substations failed to give service.

H. C. Albrecht suggested a change in the practice of holding the power factor at unity at the transformer to maintaining the power factor at unity in the armature of the rotary. He called attention to a case where a large converter had been burned out by the heavy circulating currents necessary to obtain unity power factor at the transformers. The speaker also recommended that the use of power factor be discontinued and reactive factors be adopted for use in synchronous-converter operation.

D. W. Roper said that the synchronous power of rotary converters—that is, their sensitiveness to disturbances on the system—was a factor that should be given careful consideration in their application. He said that in tests made on the Commonwealth Edison Co.'s system some years ago, it was found that under abnormal conditions the split-pole type converter would disconnect first, induction-regulator type next and the synchronous booster type third. The speaker also recommended making provisions in each substation for starting at least one machine from the alternating-current side to facilitate getting the station back into service in case of a complete interruption.

F. A. E. S. Working for Patent Office Relief and New York State Reorganization

The Federated American Engineering Societies is already showing signs of a coming activity and importance in public affairs. Although unsuccessful so far in its efforts on behalf of the Nolan Treaty Patent Bill, which is considered most important by inventors, the organization is planning to redouble its efforts to have this bill passed at the coming extra session of Congress. This work is to be in charge of the committee on patents of American Engineering Council, the governing body of the Federation. Edwin J. Prindle, of New York, who is chairman of the committee, declared in a recent report to L. W. Wallace, secretary of the Council, that the cause of the Nolan Bill's defeat was the Federal Trade Commission section and that this section should be eliminated. It is understood that this will be requested of Congress at the next opportunity.

While the most frequently heard argument in favor of the patent bill is based on the need of more pay for Patent Office employees, another phase of the question, concerning national obligations, has been frequently pointed out by the committee. The war prevented a great many inventors in this and other countries from filing foreign patents, and so other governments have made extensions of the time during which applications might be filed in a country foreign to the inventor without loss of prior rights. The Nolan Bill provides for similar action on the part of the United States, and it is stated that in the absence of such action foreign governments, naturally enough, will refuse to give any extension of time to American inventors. This reason for passing the bill, therefore, is chiefly the need for giving American inventors the opportunity to enter foreign fields successfully.

The Federation's efforts to have this legislation put through are but one example of its many and increasing activities; another example may be found in its present agitation for the reorganization of the government of New York State. Although the Federation is a national body, it has gone into this particular state matter because of the problem's peculiarly great importance and because of the good influence upon National Government that would result from a decisive change for the better in New York State. Accordingly, a committee on New York State government has been appointed, consisting of H. deB. Parsons (chairman), Paul G. Brown and Lewis B. Stillwell. This committee recently made a report to the chairman of the Joint Judiciary Committee of the state senate and assembly in which the case was plainly put. "Any corporation or business interest would go into bankruptcy if its affairs were conducted as are those of the State of New York," is the way the committee sizes up the situation.

As a solution, support is urged for the three state reorganization amendments, which provide for consolidation of state departments, for an executive budget system and for a four-year term for executive officers. Attention is called to the great economies possible, especially in handling engineering work; the elimination of duplicate functions and the general simplification of government bodies are pointed out as obvious needs, and it is further declared advisable to centralize authority as far as possible under one man, so as to get concerted action without the usual delays. Extension to four years of the terms of the governor, lieutenant governor, comptroller and attorney general are urged by the committee as necessary to give these executives time to devise and carry out constructive programs.

Activity along these lines indicates that the Federation is making an effort to grasp its opportunities for public service.

Engineers' Exchange Organized in Chicago

An engineers' exchange has been organized and incorporated recently in Chicago for the collection and distribution of information for engineers, architects, builders, contractors, manufacturers and clients. The association will have three classes of membership. Active members will be engineers in Chicago and the immediate vicinity; associate members may be individual engineers, architects, contractors, manufacturers, etc.; and engineers in other cities may become corresponding members. Active members must be practicing engineers, and it is a requirement that they be elected unanimously. They then become stockholders of the association and their shares are not transferable. Associate and corresponding members are subscribers to the exchange and have all the privileges of the members except the control of the policy of the association.

As this is a day of specialists, it is the intention to include in the membership men having special knowledge on all branches of engineering. These men will help each other for a nominal fee, and if a client desires information or service on a special subject, he will be referred to those best qualified to give it, insuring in this way better service to the public and upbuilding of the profession's prestige.

In the office of the exchange there is a comprehensive file on engineering data and indices to engineering literature, so that certain services may be attended to directly, and if not, the client may be referred to the best authorities among the membership. It is also the intention to provide a central office for business and professional conferences, to assist in the selection, purchase and shipment of materials and equipment and to give service as adjusters or arbitrators in the determination of rights by negotiation and valuation in preference to litigation. John Ericson, consulting engineer for the City of Chicago, is chairman of the exchange and J. W. Pearl is manager. Other members of the board of trustees are John P. Cowing, of Chicago; M. L. Jones, of Benton Harbor, Mich.; and A. L. Burridge, of Crystal Falls, Mich. The local address is 30 North La Salle Street.

Early Engineering.— Instances are on record where, by an excess of free caloric, fir has been inflamed when laid on the top of a boiler and lead joints in the engine melted. I have often found tin-soldered joints in the steam pipes melted by overheated steam. Dr. Ernst Alban, in "The High-Pressure Steam Engine" (1847).

Calumet Station of Commonwealth Edison Company

In the southern part of Chicago on the Calumet River the Commonwealth Edison Co. is erecting a new power station. The construction work is progressing actively, and it is planned to have the first unit in operation in October of this year.

Following the policy of the company of having provision for coal storage directly at the plant and thereby insuring continuity of service in the event of trouble either at the mines or with the freight system, the site on which this new station is being built is a large one, being 43 acres in extent. The Calumet River borders the tract at the east and the Chicago & Western Indiana Ry. and the Pennsylvania Lines border on the west. The station is designed for six units, but only sufficient is now being built to house the two units that are to be put in service this year. The axis of the station lies east and west and directly north of 100th St. The first section from the street is the switchhouse and the boiler room is at the north end.

The present units are three-phase 60-cycle 12,000-volt machines, rated at 30,000 kw., the speeds being 1,800 and 1,200 r.p.m., respectively. The switchhouse will contain a novel change in the design from the former arrangement used by the company. The new feature, designed by B. G. Jamieson, engineer of inside plant for the company, consists in separating the phases so as to remove all possibility of phase-to-phase trouble and at the same time resulting in a higher factor of safety in the oil switch layout.

Steam for the two units will be supplied by seven cross-drum boilers of the two-stage type, each having 15,089 sq.ft. of steam-making surface. Above the boiler proper and set crosswise will be the second stage, containing about 9,600 sq.ft. of surface, through which the feed-water will pass on its way to the steam generator. In other words, the second stage, to all effects and purposes, will be a high-pressure economizer. At the turbine the steam pressure will be 300 lb. gage and the superheat 225 deg., giving a final steam temperature of approximately 650 deg.

Each boiler will be equipped with two forced-draft chain-grate stokers having a total active area of 376 sq.ft., which to the steam-making surface bears the ratio of 1 to 40. The stoker is thus relatively large, and with forced draft operation at high ratings should be easily maintained. There will be complete equipment for the handling of coal and ash, and throughout the station will be substantial and modern to the last detail.

Marshall & Fox are the architects for the building, Sargent & Lundy are the steam engineers, and the company's own engineering department is designing the electrical installation.

State Development of Water Power Opposed

Governor Miller of New York has sent a special message to the legislature in which he said that private capital would be able to back needed water-power development in New York and that the state itself should not go into any such projects unless private capital should ignore the public interest. As for the latter possibility he felt that once the state adopts a definite water-power policy, the corporations involved will be more inclined to be reasonable. The governor favored strongly the earliest possible development of water power and estimated that there is 1,000,000 hp. available, but he insisted on private initiative in its utilization because he thought it could do the work better.

He asked for legislation drawn along the same general lines as the Federal Water Power Act and providing for a state water-power commission that would have power to issue licenses for new work. The State Public Service Commission would have charge of the operation of plants, including rates and the floating of securities. The plan includes favoritism in the taxation of utilities as compared to projects supplying power for private use. He criticized the Federal measure as "an infringement upon the sovereign power of the state," but said that in the main it is well drawn.

When questioned about the condemnation law's application to water power, the governor said that it was his idea "to make it possible to have the power of eminent domain fully exercised." With reference to the Niagara Falls Development Co., he explained that under his plan this company would not have to get a license, as that would be required only in cases of new projects, but would, of course, be subject to regulation. He thought it likely that the Federal Administration would take up the question of additional development at Niagara Falls and that the treaty with Great Britain would be amended so as to make possible the entire practicable diversion.

Governor Miller made an interesting remark in this connection which seems to indicate "superpower," although he did not mention the word. "I am looking ahead to a time," he said, "when there will be one common transmission system for separate projects which will take the electricity from each and distribute it."

It is said to be doubtful whether there is enough time left in the present session of the legislature to make a law of the governor's plans for a state water-power commission.

California Oil Shortage Causing Uneasiness

The consumption of fuel oil in California so greatly exceeds the production that the situation is becoming alarming, according to a recent bulletin of the Bureau of Economics of Sacramento. This bulletin contains a most emphatic plea for the development of hydro-electric power to alleviate the oil shortage and to avoid a possible rationing of oil. It declares it to be impossible at the present time for large users of fuel oil in California to contract for oil for future delivery at a given price, or even in given quantities.

This condition is ascribed largely to increased steamship and navy operation and to the continued use of fuel oil by railroads and public utility companies. The prediction, made during the last six months, that the oil supply would increase faster than the demand is described as false, the consumption having increased so fast that it has counterbalanced the greater production and the lull in some lines of industry. It is stated that had it not been for this lull the situation would have very nearly resulted in an oil famine.

The proposed remedy is to reduce demand by conservation and by development of water-power; and it is added that the oil companies do not regard hydro-electric development as competitive or dangerous to their interests, but on the contrary are entirely in favor of it. Support is urged for the water-power development program outlined by the State Railroad Commission and the Governor of California, regardless of a possible resulting increase in hydro-electric rates.

Power Development on Colorado River

Acceptance by the Federal Power Commission of the application of the Southern California Edison Co. for a preliminary permit to develop 2,500,000 hp. on the Colorado River has paved the way for an undertaking of tremendous importance. The extent of the project is best brought out by the fact that the total horsepower to be developed is almost a third of the amount of water power now being used in the United States.

The annual run-off of the Colorado River is 16,000,000 acre-feet, but as this varies greatly with the seasons a large storage basin is planned which is to be more than 200 miles long and is to have a capacity of about 40,000,000 acre-feet. This will not only give a steady flow, but will produce the very important incidental result of practically eliminating seasonal floods, which have caused a great deal of trouble in the past. It will also permit of more extensive irrigation.

New Publications

NOTES ON SMALL FLOW METERS FOR AIR, ESPECIALLY ORIFICE METERS. By Edgar Buckingham. Published by the Bureau of Standards, Department of Commerce, Washington, D. C. Paper, 10 x 7 in.; 16 pages; 1 table; 1 chart. Obtainable on application to Bureau of Standards, Washington, D. C.

This is Technologic Paper No. 183 of the Bureau of Standards and was prepared at the request of the Chemical Warfare Service, primarily for the use of its physiologists, later calls for information of the same character having made publication desirable. The paper contains data for use in selecting or designing suitable orifices and a deduction of the required equation. It also includes comments on some simple forms of flow meters obtainable on the market, with suggestions for carrying on experiments.

THE WELDING ENCYCLOPEDIA. By L. B. Mackenzie and H. S. Card. Published by the Welding Engineer Publishing Co., Chicago, Ill., 1921. Cloth; 6 x 9 in. 326 pages; 375 illustrations. Price $5.

Autogenous welding is a rapidly growing art, and as a result many new terms and words have been coined to give expression to these processes. All these words and terms are defined and illustrated in this encyclopedia. An effort has been made to cover the entire subject of autogenous welding, and this has been approximated to a creditable degree. The idea in the presentation has been to enable the welder to understand his work better no matter what the process may be. The oxyacetylene, electric-arc, electric-resistance and thermit processes are treated in separate chapters which give instruction for welding various materials by each of these methods. Another chapter is a compilation of the rules and regulations of various states, the Department of Commerce, the Interstate Commerce Commission, the A. S. M. E. Boiler Code Committee, the Master Car Builders, Lloyd's Register of Shipping, the Underwriter's Laboratories and the National Board of Fire Underwriters. In a group of charts is shown the right and the wrong way of preparing welds. One chapter is devoted to the welding of boilers. The book contains a wealth of practical information on welding and should find a wide and useful field in the advancement of the art of making welds.

THE COMPRESSION REFRIGERATING MACHINE; THE WET AND DRY COMPRESSION SYSTEMS. (Die Kompressions-Kaltemaschine-der Nasse und Trockene Gang der Kompressions Kalti-Maschine). By Dr. Ing. W. Koeniger. Published by Olderbourg, Munich, Germany.

The basis of this book is the data secured from tests by the author on a sulphur-dioxide refrigerating plant in the mechanical laboratory of the technical college at Berlin, Charlottenburg. The compressor used in these tests had a 300-mm. (11.8-in.) bore and a stroke of 120 mm. (4.72 in.); the maximum speed reached was 336 r.p.m. In the first chapter is shown the Rankine cycle on the temperature-entropy and on the entropy-total heat diagrams. Then follows a detailed description of the tests and the heat balance for each one. In chapter 4 the author takes up the problem of volumetric efficiency; in the succeeding chapter he computes this efficiency for each test. He shows how the true volumetric efficiency changes with the conditions of the vapor in the suction elbow; with 80 per cent dry saturated vapor the true efficiency was 57.5 per cent, while with 100 per cent saturation vapor the efficiency reached 75 per cent; with superheat 83.75 per cent volumetric efficiency was secured. In chapter 6 the author discusses the formula for polytropic compression and shows that the exponent m in the equation $P\ V^m = K$ varies during compression. He then develops a method of finding the exponent for each piston position. He states that the exponent is constant for only a small part of the stroke, ranging at other portions of the stroke from 1.2 to 1.0. His method consists in plotting the compression curve on logarithmic cross-section paper, finding the value of the exponent from the slope of the line.

This theory is in direct contradiction to that expressed by J. Paul Clayton in his paper, "A New Analysis of Cylinder Performance of Reciprocating Engines." Mr. Clayton found, after an examination of about 300 $P\ V$ diagrams from engines using steam, gas, air and ammonia, that the expansion and compression of an elastic medium taking place in a cylinder very closely approximates the law of $P\ V^m = K$. Mr. Clayton, who plotted the expansion curves on logarithmic paper, found that the curves now became straight lines; he then calculated the clearance volume from the straight-line exponent curves.

Two radically differing theories are now offered. The Koeniger theory shows how to find the varying values of the exponent m, while Clayton's, assuming a constant value of m, uses this constancy to find cylinder clearances.

In an appendix is shown how refrigerating plants can be designed by means of the entropy diagrams. Eight large charts are included in this volume, being the entropy charts for SO_2, CO_2 and NH_3, also total heat diagrams for CO_2, SO_2 and NH_3.

The book will be valuable to refrigerating engineers, especially because it is based on actual tests, and students of thermodynamics will welcome it as a means to make themselves acquainted with calculations of refrigerating plants using the entropy and entropy-heat diagrams. It is to be hoped that the work will be translated and published in English.

The book is well printed on good paper, drawing and diagrams are clearly cut and come up to the standard expected from publishers like Oldenbourg.

CHARLES H. SANWALD.

SAFETY, SANITATION AND WELFARE

The Bureau of Safety, Sanitation and Welfare of the United States Steel Corporation has prepared an unusually comprehensive and interesting bulletin No. 8, describing personnel work in the various plants of the corporation. The booklet contains 96 pages, 8½ x 11 in. in size, and is largely devoted to well-prepared illustrations.

Personals

Auguste C. E. Rateau, famous French engineer and inventor of the Rateau turbine, has been made a Chevalier de la Légion d'Honneur.

William McClellan, Philadelphia, Pa., has been announced as the sole nominee for the office of president of the American Institute of Electrical Engineers.

Prof. Frank Aydelotte, American secretary to the Rhodes Scholarship trustees and professor of English at Massachusetts Institute of Technology, has been chosen president of Swarthmore College.

Gardner C. Derry, formerly district manager of the power apparatus department of the New York office of the B. F. Sturtevant Co., is now at the factory home office at Hyde Park, Boston, in charge of the fuel economizer and mechanical draft department.

John F. Layng, for many years with the railway and traction engineering department of the General Electric Co., has gone into the consulting engineering field as a partner in the firm of Hemphill & Wells, of New York City.

Charles C. Gardner, New England States Deputy of the N. A. S. E. and until recently chief engineer at the Chandler Oil Cloth Co., East Taunton, Mass., has accepted a position as general supervisor of installation and maintenance at the Keene Wooden Ware Co.'s plant in Keene, N. H., where new equipment throughout is being installed.

John T. Sharp, Jr., superintendent of the Canton Electric Light and Water Works, has been made manager of the newly organized Winona Public Utility Plant. This plant is a reorganization of the Winona Light, Ice, Water and Sewerage Co., which the City of Winona has purchased and remodeled so as to provide water and light services for the entire city.

Society Affairs

Philadelphia Section, A. I. S. E. E. will meet April 2 to hear D. M. Petty, of the Bethlehem Steel Co., speak on "The Generation of Power in Steel Mills."

Philadelphia Section, A. S. M. E., is to hold a Students' Night meeting on April 1. The speakers will be William D. Disston, Hugo Bilgram, C. N. Lauer, W. C. L. Eglin and J. G. Strachan.

The National Association of Stationary Engineers will hold its annual convention in September at Springfield, Mass., instead of at Rochester, N. Y. The latter place was chosen by the delegates last year out of a number of cities seeking to entertain the convention, but was unable to perfect the arrangements necessary for its accommodation.

Metropolitan Student Branch, A. S. M. E., is to hold its annual meeting April 1 at 4 p.m. at the Engineering Societies Building, New York City. George Kingdon Parsons will talk on "Psychology in Engineering," and W. S. Murray on "The Superpower Zone." After a buffet supper the management section will provide a program on "Management."

New York Section, A. I. E. E. and Metropolitan Section, A. S. M. E., will hold a joint meeting March 25 at 8 p.m. to discuss "Industrial Relations." Prof. Walter Rautenstrauch will have charge of the meeting, and the speakers will be Dr. F. H. Giddings, Dr. Ira N. Hollis, Dr. D. S. Kimball, Dr. S. M. Lindsay, L. P. Alford, E. W. Tree, and A. L. De Leeuw.

The Providence Engineering Society has prepared a very serious professional meeting in the nature of a "Free Power Symposium and Spring Smoker," to be held March 29 at 8 p.m. The program announces a number of highly technical papers, one of which will describe a scheme for utilizing free power by heating pavements electrically to prevent snow adhesion.

Miscellaneous News

An English Research Worker, G. O. Calvert, claims to be able to make synthetic alcohol on a commercial scale for a selling price of 20 pounds sterling a ton.

A $2,000,000 Electric Generating Station is being planned by the Potomac Electric Power Co., of Washington, D.C. The company expects to have the work under way during the coming year and to have the plant in operation early in 1922.

Two of The Engineer's License Laws advocated by the American Association of Engineers have been passed: in Indiana, where the governor has signed the bill, and in North Carolina, where the bill is ready for the governor's signature. There are 21 other states considering similar bills.

Greater Diversion of Water Power at Niagara is the object of a resolution introduced in the New York State senate recently by Senator Gibbs, of Buffalo. The resolution calls upon the President, Secretary of State and Members of Congress from New York to try to amend the treaty between the United States and Canada to permit of using 40,000 cu.sec.-ft. on each side of the Falls. At present only 20,000 may be taken on the American side and 37,000 on the Canadian side.

The Senator said that engineers had reported that the proposed diversion of 80,000 cu.sec.-ft. would not impair the beauty of the Falls.

Business Items

The Empire State Engine Corp. has moved from 1261 Broadway to 347 Madison Ave., New York City.

The Barber-Greene Co., Aurora, Ill., has announced that H. S. Greene has been elected vice president in charge of sales. Mr. Greene was for several years assistant sales manager of the National Carbon Co.

Manning, Maxwell & Moore, Inc., 119 West Fortieth St., New York City, has taken over the merchandise and good-will of Patterson, Gottfried & Hunter, New York hardware dealers. Liquidation is to take effect May 1.

W. N. Best, Inc., has sold its business to the W. N. Best Furnace and Burner Corp., which was incorporated under the laws of New York with a capitalization of $1,000,000. The new company will organize branches in every foreign country where oil fuel is used and will exploit the various inventions developed by the former corporation. Dr. W. N. Best, F. R. S. A., who was the president of W. N. Best, Inc., has made a study of oil and tar burning for the last 33 years and has written a book on "The Science of Burning Liquid Fuel." Dr. Best has a large financial interest in the new company and is to be its consulting engineer.

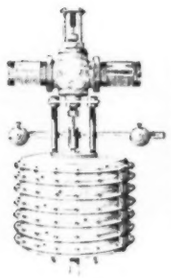
Condensed-Clipping Index of Equipment

Patented Aug. 20, 1918

Valve, P. & K. Air Pressure Controlling

Pitts & Kitts Manufacturing and Supply Co., 50 Park Place, New York City

"Power," Feb. 1, 1921.

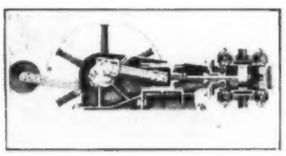


This air-pressure controlling valve is designed for controlling the forced- or induced-draft fans supplying air to boiler furnaces, and for controlling the predetermined flow of air in heating and ventilating systems. When the steam pressure increases, it operates the damper regulator that closes the valve, which causes the fan speed to be reduced. With a steam-pressure drop of ½ lb. the regulator opens the valve and causes an increase in the speed of the fan, thus building up the air pressure in the main.

Compressor, Pennsylvania Air

Pennsylvania Pump and Compressor Co., Easton, Pa.

"Power," 1921.

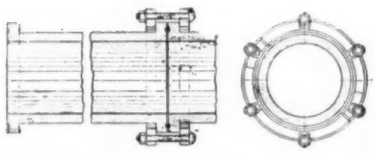


This vacuum pump is of the inclosed dirt- and dust-proof construction, providing for a splash lubrication system for the driving parts. An oil float gage indicates the level of the oil in the basin. A forged crankshaft is used which permits the employment of a solid box at each end of the connecting rod. The solid flywheels are mounted on the tapered ends of the crankshaft, keyed and are held in place by a washer and cap bolt. The ring plate type of valve used is guided on the outside in place of inside the valve, making it impossible for the valve to cock in operation. A vacuum pump is also made and is of the same general construction as the compressor excepting that the air cylinder of the vacuum pump is of considerably greater diameter for the same stroke size and the positions of the valves are reversed. That is, where the discharge valves are at the top in the air compressor, they are placed at the bottom in the vacuum pump. These machines are built both power and steam driven.

Joint, Improved Ash Conveyor Flange

M. H. Detrick, 549 West Washington St., Chicago, Ill.

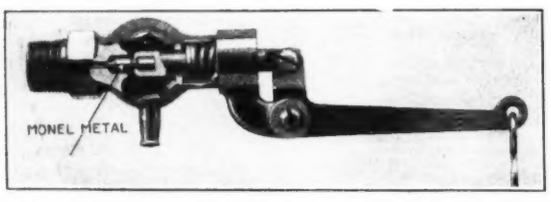
"Power," 1921.



This improved pipe flange is cast solid and the pipe connections are formed by the use of a flange coupling or collar, cast in two sections to form a circle that girdles the pipe just outside the flanges. Bolts connecting these collars draw them together with the pipe flanges between, forming a joint without strain on the pipe. The pipe end is grooved 1 in. from the inside surface of the pipe to receive a rubber ring gasket to complete the airtight joint and at the same time permit the necessary flexibility to provide for the expansion of the pipe. The gasket can easily be inserted after the pipe flanges are brought close together. This movable flange coupling obviates the trouble of non-alignment of bolt holes when cast in pipe flange.

Cock, New Reliance Gage

The Reliance Gage Column Co., 5902 Carnegie Ave., Cleveland, Ohio. "Power," 1921.



In this valve monel metal is used in resisting steam cutting and corrosion. The monel-metal disc seats against the pressure on a narrow seat of bronze. The seat is made tight by tapping with a hammer on the projecting end of the stem. The disc is held on the seat against the pressure by a copper-coated steel spring. Packing is placed around the stem to cause all the discharge to take place through the nozzle. The cock is operated by a single chain pull.

Drill, Wodack Portable Electric

Wodack Electric Drill Corporation, 23 So. Jefferson St., Chicago, Ill.

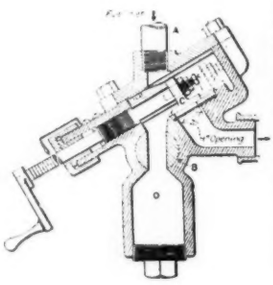
"Power," 1921.

This portable drill is motor-driven, using either alternating or direct current and automatically stops when not in use, because the current contact functions through a spring lever in the handle, which is released as soon as the pressure of the operator's grip is removed. This drill is made in six sizes; the ¾-size has two speeds. In addition to the drill a portable grinder is made and equipped with the same novel style of control. These grinders are made in three sizes, depending on the wheel capacity, 3 x ½, 4 x 1, and 8 x 1 inch.

Valve, Rigby Liquid Fuel Regulating

Bailey-Lewis, Inc., 406 Bakewell Bldg., Pittsburgh, Pa.

"Power," Jan. 11, 1921.

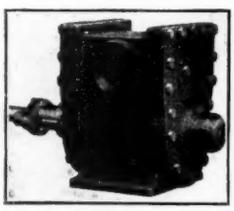


This valve is designed to deliver to fuel-oil burners a constant flow of fuel of varying viscosity and in quantities to secure proper combustion. The feature of the valve is a triangular aperture in the valve seat and a sliding, shearing valve running in a groove cut in the face of the seat. This movement regulates the flow of oil by opening and closing the aperture. Sediment can be cleaned out by turning the handle of the valve which closes it. The trap can be cleaned without stopping the flow of oil through the valve by turning a stop cock and removing a plug in the bottom. A locknut arrangement makes it possible to set the valve for any required quantity of fuel.

Pump, St. Louis Rotary Piston

St. Louis Pump and Equipment Co., St. Louis, Mo.

"Power," 1921.

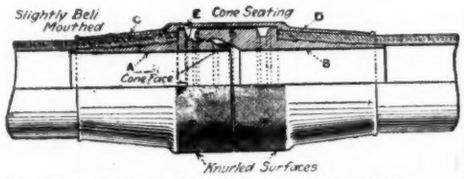


The pump consists of a case with dividing partition; two end plates; a steel shaft with two eccentrics mounted thereon; two pistons, two rocker arms; and two checks. The two eccentrics 180 deg. apart are mounted on the shaft. Surrounding these eccentrics are two pump pistons, pivoted to the rocker arm which produces the reciprocating movement of the piston through the cam action of the eccentrics. A composite reciprocating and rotary motion of the pump plunger or piston without actual contact of piston and cylinder walls is thus obtained. The clearance is so small that a liquid seal results. The piston check is the only moving part touching the cylinder wall, and this functions only at the point of transition at the end of the pumping suction movement or stroke to the beginning of a new stroke. The head at one end of the pump case is blind. At the other end a gland holds the packing material.

Coupling, New Hose

From the "Engineer," London, England

"Power," Jan. 25, 1921



This coupling is designed to suit all sizes and varieties of either rubber or metallic hose. It consists of two spigots and two sleeves. One sleeve is passed on the hose, and one of the spigots is pushed into the bore of the hose. The sleeve is then drawn up into position and held in place by a screw. The other spigot and sleeve are applied to the end of the other hose length in the same way. The coupling of the two hose lengths is effected by giving them a preliminary twist in opposite directions, inserting one spigot within the other and screwing the ends around so as to engage the threads on the spigots and cause the one cone face on the end of the spigot to make a tight contact with the conical bore of the other spigot.

Clip, paste on 3 x 5-in. cards and file as desired

FUEL PRICES

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run basis, f.o.b. mines):

Coal	Market Quoted	Mar. 8, 1921	Mar. 15, 1921
Pocahontas,	Columbus	$3.50	$3.50
Clearfield,	Boston	2.55	2.00@3.00
Somerset,	Boston	3.15	2.40@3.60
Pittsburgh,	Pittsburgh	2.35	2.00@2.50
Kanawha,	Columbus	2.25	2.25
Hocking,	Columbus	2.15	2.25
Pittsburgh No. 8	Cleveland	2.35	2.00@2.25
Franklin, Ill.,	Chicago	2.65	2.25@3.50
Central, Ill.,	Chicago	1.35	1.50@2.50
Ind. 4th vein,	Chicago	2.60	2.25@3.00
Standard,	St. Louis	1.95	1.90
West Ky.,	Louisville	2.40	2.35@2.50
Big Seam,	Birmingham	2.95	2.70@3.25
S. E. Ky.,	Louisville	2.75	2.75

DIESEL FUEL OIL

Chicago—24@28 deg. Baumé, $1.10@$1.20 per bbl.; 32@34 deg., 3¾@4¼c. per gal.

Cincinnati—In 8,000-gal tank cars; 26@28 deg., 9¾c. per gal, 30@34 deg., 10c.

St. Louis—March 12 prices, f.o.b. cars, tank lots: 22@26 deg. Baumé, 4¼c., 32@34 deg., 2¾c.; 16@20 deg. 4¼c.

Baltimore—On March 12, f.o.b. Baltimore in tank-car lots: 26@28 deg. Baumé, 7¾c.; 30@34 deg., 7¾c.; 16@20 deg., 5.35c. per gal. or $2.25 per bbl., 15 deg., 5.6c. per gal.

Pittsburgh—On March 14, f.o.b refinery: 24@30 deg. Baumé, 80@85c. per bbl.; 32@34 deg., 2¾c. per gal.; 36@38 deg., 3¼c.; 38@40 deg, 4c.

New Construction

PROPOSED WORK

Vt., Middlebury — The Hortonia Power Co. plans to rebuild a 1 story power plant which was recently destroyed by fire. About $100,000.

Mass., Boston—The Olympia Realty Co. is having preliminary plans prepared for an 11 story office and theater building on Washington St. About $1,200,000. Mowll & Rand, 50 Bromfield St., Archts.

R. I., Pawtucket—The Broad St. Power Co., Broad St., is having plans prepared for a 2 story theater. About $500,000. J. E. O'Malley, 75 Westminster St., Providence, Archt.

Conn., Hartford—The Health and Charity Dept., rejected all bids for a 2 story, 43 x 63 ft. central heating plant and laundry on Vine St. About $80,000. R. D. Kimball Co., 6 Beacon St., Boston, Mass., Engr. Whiton & McMahon, 36 Pearl St., Archts. Work will be readvertised.

Conn., New Britain—The Fox Amusement Co., 130 West 46th St., New York City, plans to build a theater and office building on Main St. About $1,000,000.

Conn., New London—The Bd. of School Comrs. will soon award the contract for a 2 story, 100 x 310 ft. high school including a steam heating plant on Williams St. About $500,000. D. S. Donnelley, Plant Bldg., Archt.

Conn., Waterbury—B. J. Torkomian, 53 Leavenworth St., plans to build an 8 or 10 story apartment house on Grove St. About $500,000. Architect not yet selected.

N. Y., Hornell—The Bd. Educ. plans to build a high school including a steam heating system. About $450,000. Tooker & Marsh, 101 Park Ave, New York City, Archts. and Engrs.

N. Y., Jamaica, L. I.—The Bd. Educ., 500 Park Ave., New York City, plans to build an addition to the high school here including a steam heating system. About $500,000. C. B. J. Snyder Municipal Bldg., New York City, Archt. and Engr.

N. Y., New York—(Brooklyn Boro) The Dyken Constr. Co., c/o Shampan & Shampan, archts. and engrs., 50 Court St., is having plans prepared for an apartment house including a steam heating system on 20th Ave. South of 86th St. About $250,000.

N. Y., New York—(Bronx Boro) The Burnside Theater Corp., 2176 Grand Concourse, is having plans prepared for a 1 story, 105 x 165 ft. theater and store building including a steam heating system on Burnside Ave. About $250,000. Springstein Goldhammer, 32 Union Sq., Archts. and Engrs.

N. Y., New York (Manhattan Boro)—The Bar Assn., c/o H. Craig Severance, Archt. and Engr., 372 Lexington Ave., plans to build a 16 story office building, including a steam heating system at 34-36 West 44th St. About $1,350,000.

N. Y., New York—(Manhattan Boro) The Pershing Sq. Bldg. Corp., c/o J. Sloan, Archt. and Engr., 570 5th Ave., is having plans prepared for a 24 story office building on Pershing Sq., 42d St. and Park Ave. About $5,000,000.

N. Y., Niagara Falls — The Cataract Theater Corp., 31 Falls St., is having plans prepared for a 3 story, 154 x 175 ft. play house and store building. About $700,000. H. L. Spann, 52 West Chippewa St., Buffalo, Archt.

N. J., Lakehurst—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., plans to install additional wells and pumping machinery, here.

Pa., Philadelphia—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., received bids for an electric power distributing system for shipbuilding slips 2 and 3 at the Navy Yard, here, from the George Constr. Co., 407 Stock Exchange Bldg., $23,112; George Woodward, Jr., 1723 Sansom St., $29,200; Mack & Mack, 103 Park Ave., New York City, $31,800.

Md., Baltimore — The Zirconium Co. of America, Inc., 1036 Calvert Bldg., G. F. Dixon, Pres., is in the market for a one 50 or 75 kw., a.c., 60 cycle, 110 to 220 volt generator.

Va., Quantico—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., plans to install an electric light and power system, here.

N. C., Chapel Hill—The University of North Carolina plans to build college buildings. About $1,490,000. Architect not yet selected.

N. C., Graham—The city will receive bids until March 30 for two pump stations, etc. About $100,000. Norcoss & Keis, Atlanta, Ga., Engrs.

N. C., Sanatorium—The North Carolina Tuberculosis Hospital plans to build a hospital. About $300,000. Architect not yet selected.

Fla., Jacksonville — Farris & Co., 410 Davis St., plans to build a 3 story, 75 x 100 ft. cold storage plant for meat packing and install equipment in same. About $50,000.

Ky., Dawson Springs—J. A. Wetmore, Supervising Architect, Treasury Dept., Wash., D. C., will receive bids until March 28 for a power plant at the Public Health Sanatarium, here. About $150,000. Bids for mechanical equipment will be received later.

O., Akron—The Akron Prospect Co., Main and Market Sts., will soon award the contract for the superstructure of a 10 story, 135 x 225 ft. theater and hotel building including a steam heating system on Prospect and Park Sts. About $3,000,000. John Eberson, 64 East Van Buren St., Chicago, Archt. Leiberman, Klein & Heni, 190 North State St., Chicago, Engrs.

O., Cleveland—The city received bids furnishing 1 boiler feed water heater, from J. L. Sheldon Co., Kirby Bldg., $3,334.

O., Cleveland—F. C. Newcomer, Citizens Bldg., plans to build a 10 story, 129 x 158 ft. apartment house including a steam heating system on East Blvd. near East 105th St. About $500,000. G. B. Post & Sons, Hanna Bldg., Archts.

O., Cleveland Heights—(Warrensville P. O.) The Bd. Educ. will receive bids until April 1 for installing heating and ventilating systems in the Noble Rd. School. About $45,000. E. K. Bryan, Clk. F. C. Warner, Hippodrome Annex Bldg., Archt.

Ind., Ft. Wayne—The General Electric Co., Bway along the tracks of the Pennsylvania R.R., plans to build two 1 story transformer buildings. About $75,000.

Ind., Indianapolis — The Indianapolis Water Co., 113 Monument Pl., plans to build a 259 x 547 ft., reservoir to have a capacity of 10,000,000 gal. Five electrically driven centrifugal pumps will be installed. About $285,000. B. J. T. Jeup, 2415 Fulton Talbot Ave., Engr.

Ind., Indianapolis—The Riley Memorial Hospital plans to build a hospital on West Michigan Ave. About $1,000,000. Architect not yet selected.

Ind., Kendallville—The city will receive bids until April 7 for furnishing new equipment including three 300 hp. water tube steam boilers. C. Michaelis, City Clk.

Ind., Richmond—The city plans to install strainers or traveling screens in the power plant here. About $4,000. J. D. Lyon, Union Central Bldg., Cincinnati, O., Engr.

Ind., Terre Haute—Crawford Fairbanks, Tribune Bldg., is having plans prepared for a 5 story, 124 x 140 ft. store and mercantile building on Wabash Ave. About $250,000. W. E. Russ, 200 Meridan Life Bldg., Indianapolis, Archt.

Mich., Detroit—Maurice H. Finkel, Archt., Majestic Bldg., is preparing plans for a 4 story, 85 x 153 ft. apartment house including steam heating equipment on Woodward and Collingwood Aves. About $500,000. Owner's name withheld.

Mich., Detroit—J. A. Martin, Comr. of Pub. Wks., will receive bids until March 24 for a 1 story, 48 x 202 ft. sewage pumping station including steam power equipment to operate pumps at Fairview Station. About $80,000. Smith, Hinchman & Grylls, 710 Washington Arcade, Engrs.

Mich., Detroit—The United Savings Bank, Griswold St., plans to build a 6 story, 60 x 72 ft. bank and office building including steam heating equipment. About $300,000. A. Kahn, 1000 Marquette Bldg., Archt.

Ill., Belleville—The Unit Stove & Furnace Co., H. A. Langfelder, Purch. Agt., is in the market for motors, air compressors, etc. (new or used).

Ill., Champaign — The Hotel Co., c/o Peter Jones, Atty., is having preliminary plans prepared for a 12 story hotel and theater building. About $700,000. C. Howard Crane, Elmer G. Kichler and Cyril E. Schley, Huron Bldg., Detroit, Mich., Archts.

Ill., Chicago—A. J. Sheridan, c/o L. C. Bouchard & Co., Archt., 30 North Dearborn St., will soon award the contract for a 7 story, 80 x 120 ft. hotel including a steam heating system on Rogers Ave. and Lake Terrace. About $500,000.

Ill., Chicago—The West End Hospital, 2058 West Monroe St., is having plans prepared for a 6 story, 50 x 100 ft. hospital including an addition to steam heating plant. About $350,000. D. S. Klafter, 64 West Randolph St., Archt.

Ill., Herrin—The Herrin Hotel Co., 907 Fletcher Savings & Trust Bldg., Indianapolis, Ind., is having plans revised for a 3 story, 109 x 136 ft. hotel on 14th and East Madison Sts. About $250,000. J. B. Scribbins, 401 Powers Bldg., Decatur, Ill., Archt.

Wis., Fond du Lac—The Loyal Order of Moose, Main St., is having preliminary plans for a 4 or 5 story hotel and lodge building. About $400,000. M. Tullgren & Sons, 425 East Water St., Milwaukee, Archts.

Wis., Kilbourn—W. R. Weir, is in the market for motors and ice cream making machinery.

Wis., Manitowoc—The Chamber of Commerce plans to build a several story hotel on North 8th St. About $500,000. Architect not yet selected.

Wis., Milwaukee — Cahill & Douglas, Engrs., 217 West Water St., will soon award the contract for a 150 kw. belted generator and will later receive bids for 200 hp. electric motor, for the Abresch Co., 399 4th St.

Wis., Sheboygan—The City will receive bids until April 4 for a 3 story, 60 x 185 ft., first unit of high school and power house including a heating system on Jefferson and 9th Sts. About $350,000. Childs & Smith, 64 East Van Buren St., Chicago, Archts. Noted June 15.

Wis., Sheboygan — The Gutsch Brewing Co., 1012 New York Ave., will receive bids until April 1 for a 2 story, 55 x 152 ft. ice manufacturing plant. About $75,000. C. F. Ringer & Son, 432 Bway, Milwaukee, Archts.

Wis., Two Rivers—The Bd. Educ. received bids for a 3 story high school and boiler house from the Schmidt Bros. Constr. Co., Reaper Blk., Chicago, $326,100; L. M. Hansen Co., 206 South Washington St., Green Bay, $347,439; Madsen & Peterson, 802 Plymouth Bldg., Minneapolis, Minn., $355,755. Noted March 9.

Wis., Whitehall — Trempealeau County, c/o J. Dewey, has extended the date of bids until March 25 for a 44 x 70 ft. power house at the asylum, here. A. D. Conover, Tenney Blk., Madison, Archt. and Engr. Noted March 9.

Minn., Bemidji—The Bd. Educ. is having plans prepared for a 2 story, 148 x 230 ft. junior and senior high school including a heating and mechanical ventilation system. About $300,000. E. F. Broomhall, 719 Alworth Bldg., Duluth, Archt. and Engr.

Minn., Minneapolis—The city, c/o C. W. Ringer, Chief of the Fire Dept., City Hall, plans to build a 3 story fire station including a steam heating system. About $300,000. H. A. Kennison, Plymouth Bldg., Archt.

Minn., Redwood Falls—The city c/o H. C. Rutter, City Clk., received bids for furnishing one 15 kw. and one 20 kw. current transformers and other apparatus to be used in connection with the ornamental lighting system it plans to install, from the Fargo Electric Co., Fargo, N. D., $16,267 and $18,657; Berger Electric Co., $15,961 and $16,,929; Duncan Electric Co., $17,281 and $17,677. (Alternate bids on different type posts). Noted Feb. 15.

Minn., South St. Paul—(St. Paul P. O.) The city will soon receive bids for one deep well, centrifugal electric motor driven pump, of 1,000 gal. capacity against a min.-max. head of 300-325 ft. or plunger type electric motor driven pump of 800 gal. per minute capacity against 350 ft. head, and one booster centrifugal pump of 250 gal. per minute capacity against 85-120 ft. min.-max. head. J. H. A. Brantz, 409 Metropolitan Opera House Bldg., St. Paul, Engr.

Kan., Atchison—Mt. Scholastic Academy is having plans prepared for a 4 story academy. About $600,000. E. Brielmaier & Sons, 432 Bway, Milwaukee, Wis., Archts. and Engrs.

Neb., Rulo—The city plans an election soon to vote on $40,000 for pumping plant and water mains. E. T. Archer & Co., Kansas City, Mo., Engr.

Mo., Joplin—The Union Iron Wks., 623-29 Kentucky Ave., will receive bids until April 1 for remodelling 2 story, 20 x 40 ft. factory and a new boiler room. About $10,000.

Ark., Paragould—W. R. Heagler & Sons, Bertig Bldg., will receive bids until April 12 for a new waterworks and power plant, for the Comrs. of the Paragould Water Dist. One 250 hp. tubular boiler, 2 engines, steam or oil, two 150 hp. boiler feed pumps, two 600 gal. capacity deep well pumps, two 100 kva., 20 volt, 3 phase, 60 cycle generators, water pumps to produce 1,000 lb. pressure per min. will be installed. About $120,000. Hiram Phillips, Fullerton Bldg., St. Louis, Mo., Consult. Engr.

Okla., Oklahoma City—The B. P. O. E. Lodge No. 417, 16½ West Main St., is having preliminary plans prepared for a 7 story home on 3rd and Harvey Sts. About $500,000. Jewell Hicks, 19½ West Main St., Archt.

Okla., Okmulgee — Smith, Rea, Lovitt & Senten, Archts., will receive bids until March 28 for a 7 story, 60 x 90 ft. bank and office building on 7th and Grand Sts., for the Commerce Investment Co., 602 Finance Bldg. About $500,000.

Col., Manitou — Pike's Peak Hotel & Amusement Co., Colorado Springs, had plans prepared for a 10 and 12 story hotel. About $1,000,000 or more. L. H. Vade, 220 South Michigan Ave., Chicago, Ill., Archt.

Utah, Ogden—E. F. Piers, Archt., Eccles Bldg., plans to build an 8 story, 60 x 175 ft. apartment house. About $350,000. Owner's name withheld.

Cal., Los Angeles—The California Lutheran Hospital Assn., c/o J. Frauenfelder, Archt., 1116 Story Bldg., is having plans prepared for a 6 story, 102 x 156 ft. hospital including a steam heating system on 15th and Hope Sts. About $700,000.

T. H., Ford Island—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., plans to install an electrical supply and distributing system, here.

N. B., Musquash — The New Brunswick Electric Power Com. plans to build a 33 x 120 ft. hydro-electric power plant along the Musquash River, here, for the Provincial Government, Fredericton, C. O. Foss, St. John, Chief Engr.

Ont., Blyth—The Council is in the market for equipment for lighting and power distribution system. About $20,000. Dr. Milne, Mayor.

Ont., Brussels—The Council passed a by-law for a hydro-electric lighting and power distribution system. About $15,000.

Ont., Kingston—The Queens University, 207 William St., plans to build a 1 story heating plant including horizontal boilers. About $125,000. Architect not yet selected.

Ont., Niagara Falls—W. J. Seymour, C'k., will receive bids for one 40 hp. power electric motor 690 r.p.m. and one 6 hp. vertical boiler with smoke stack and injector in connection with proposed asphalt plant.

Ont., Ottawa—The Ottawa Hydro Electric Com., 75 Laurier Ave., will soon award the contract for furnishing motors, transformers, wire and general supplies. J. E. Brown, Engr.

Ont., Parry Sound—The Town Council is in the market for an electric driven centrifugal pump. About $8,000. J. D. Broughton, Clk.

Ont., Petrolea—The Town Council plans to submit a by-law to provide for the extension of the electric system to operate the waterworks pumping plant, and is in the market for equipment for same. About $15,000.

Ont., Toronto — W. Price, Archt., City Hall, will receive bids until April 10 for a 1 story live stock area including a steam heating system at the Exhibition Park, for the city. Equipment for artificial ice manufacture building will be installed. About $1,000,000.

Ont., Walton—The Hydro Power Comn., University Ave., Toronto, plans to build a new distributing station here. About $25,000. Adam Beck, London, Chn.

Ont., Windsor — The Windsor Electric Comn. plans to build an addition to the electric sub-station and is in the market for additional equipment, including dynamos, transformers, etc. About $120,000. O. M. Parry, Genl. Mgr.

Sask., Swift Current—The Saskatchewan Co-operative Creamery Co. plans to build a cold storage warehouse.

CONTRACTS AWARDED

Conn., New Haven—The United Illuminating Co., 84 Temple St., has awarded the contract for a 1 story, 70 x 88 ft. boiler house addition on Grand Ave., to C. W. Murdock, Inc., 505 Grand Ave. About $40,000. Noted Dec. 7.

N. Y., New York (Bronx Boro)—The Bd. Educ., 500 Park Ave., New York City, has awarded the contract for the installation of a heating and ventilating system in P. S. No. 59 on Bathgate Ave. and 182nd St., to W. J. Olvany, 100 Charles St., New York City, at $101,913.

N. Y., New York (Bronx Boro) — The Realty Managers Inc., 200 5th Ave., will build a 6 story, 90 x 115 ft. apartment house including a steam heating system on Burnside and Breston Aves. About $250,000. Work will be done by day labor.

N. Y., New York (Manhattan Boro)—The Pub. Serv. Comn., 49 Lafayette St., has awarded the contract for furnishing and delivering a drainage pump, to the Wagner Elevator Co., Pearl St., at $1,430. Noted Feb. 1.

Pa., Philadelphia—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., has awarded the contract for an electric distributing system, to the George Constr. Co., Inc., 407 Stock Exch. About $25,112.

O., Cincinnati—The Columbia Amusement Co., c/o W. H. McElfatrick, Archt. and Engr., 701 7th Ave., New York City, has awarded the contract for a theatre and store building including a steam heating system, to G. A. Fuller, Swetland Bldg., Cleveland. About $600,000.

Ind., Terre Haute—The Indiana Theatre Co., Trust Bldg., has awarded the contract for a 3 story, 140 x 183 ft. theatre and office building on 7th and Ohio Sts., to John Shumacker, Indianapolis. About $550,000.

Mich., Allegan — The Bd. Educ. has awarded the contract for a 3 story, 160 x 200 ft. high school including a steam heating system, to Frank Dyke, Holland, Mich. About $275,000.

Mich., Bay City — The Bd. Educ. has awarded the contract for a 3 story, 270 x 270 ft. high school including a steam heating system, to H. C. Weber Constr. Co., Center Rd. About $300,000.

Ill., Elmhurst—The city has awarded the contract for a disposal plant to include pumps, etc., to Gidney & Murphy, Minneapolis, Minn. About $325,497.

Okla., Wynona—The city has awarded the contract for a water development system, to M. L. Cunningham, Empire Bldg., Oklahoma City, at $272,321. Pumps, etc. will be installed.

Ont., Ranney's Falls—The Hydro Electric Power Comn. of Ontario, University Ave., Toronto, has awarded the contract for furnishing two 5,000 hp. vertical single runner turbines, to the Boving Hydraulic Co. Ltd., Lindsay.

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